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Report of the third session

FAO EXPERT PANEL FOR THE FACILITATION OF TUNA RESEARCH

Cádiz, Spain, 7 - 10 October 1969

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1969

REPORT OF THE THIRD SESSION OF THE FAO PANEL OF EXPERTS FOR THE FACILITATION OF TUNA RESEARCH

Cádiz, 7 - 10 October 1969

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, November 1969

PREPARATION OF THIS REPORT

This is an edited and approved version of FID : EPFTR : 3/WP/13 as amended at the closing session of the Panel and which incorporates various Panel's Working Parties' reports, as well as documentation prepared for the Third Session by some members of the Panel.

Distribution

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Procedural matters. Thunnidae - taxonomy - length measurements - eggs, larvae and juveniles. Stock research - use of underwater sound. Tagging. Catch and effort statistics. International cooperation - research programmes. Regional investigations. List of documents.

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1. PROCEDURAL MATTERS

General

The FAO Panel of Experts for the Facilitation of Tuna Research convened at the Nautical School in Cádiz, Spain, from 7 to 10 October 1969, with Professor E. Postel (France) as Chairman and Dr. A. Suda (Japan) as Vice-Chairman. Dr. J. Joseph (U.S.A.) was elected Rapporteur. All members of the Panel were present, with the exception of Dr. H.Z. Vilela (Portugal) who was unable to attend. Dr. Establier and Dr. Gutierrez, scientists and tuna workers from the Instituto de Investigaciones Pesqueras in Cádiz were invited to attend as observers. A list of officers and participants is given in Appendix 10.

Agenda

The following Agenda was adopted:

1. Opening of the Session
2. Adoption of the Agenda and arrangements for the Session (WP.1 and 2, Inf.1 and 3)[1/]
3. Reports of Working Parties:
   a. Tuna taxonomy (WP.3)
   b. Tuna length measurements and tabulation (WP.4, Inf.7)
   c. Tuna eggs, larvae and juveniles (WP.4, Inf.10)
   d. Tuna tagging in the Pacific and Indian Oceans (WP.6)
   e. Tuna tagging in the Atlantic and adjacent seas (WP.7)
   f. Tuna stock assessment (WP.8)
   g. Development and use of underwater sound in tuna research (WP.9)
4. Subpopulations identification by genetic techniques (WP.11)
5. Review of tuna tags and inventory of tuna tagging programmes (Inf.9)
6. Tuna catch and effort statistics (WP.12, Inf.14)
7. Management of tuna resources (WP.8 and 10, Inf.8)
8. Training, education and exchange of workers
9. Exchange of publications
10. Review of tuna research
11. Collaboration with other bodies concerned with tuna research and management
    a. International Commission for the Conservation of Atlantic Tunas (WP.10, Inf.5)
    b. Other (Inf.6 and 7)
12. Future operation of the Panel (Inf.4)
13. Other subjects
14. Election of officers for the period between the Third and Fourth Sessions
15. Date and place of Fourth Session
16. Approval of Report of the Panel
17. Adjournment

The work of the Panel

The Panel met in plenary sessions and reviewed the present status of tuna research in the world. The reports of the various Working Parties of the Panel were discussed in light of the recommendations made by the Panel during its Second Session, and also reviewed were a number of other documents which were made available by the members of the Panel, the Secretariat, and other staff members of the FAO Department of Fisheries.

1/ All references made refer to the Working and Information papers of the Third Session of the Panel (See Appendix 11)

A list of the documents is given in Appendix 12. Papers considered by the Panel and not published elsewhere are reproduced in Appendices 1 to 9.

During the Session the participants had the opportunity to visit the laboratory of the Instituto de Investigaciones Pesqueras in Cádiz and to discuss practical aspects of tuna research.

Officers

The Panel unanimously elected Dr. A. Suda (Japan) as Chairman and Mr. J.C. Marr (U.S.A.) as Vice-Chairman for the interim period until the Fourth Session, and for the Fourth Session.

Date and place of the Fourth Session

The Panel expressed the opinion that, taking into account the experience of the Third Session, also the Fourth Session should be convened at the site of a research laboratory directly involved in tuna investigations. It was recommended that the Fourth Session be held in the Indo-Pacific area in about three years' time, if possible at the Biological Laboratory of the U.S. Bureau of Commercial Fisheries in Honolulu, Hawaii. The Secretary of the Panel was requested to follow up this matter in consultation with the Chairman.

Relations with the Advisory Committee for Marine Resources Research (ACMRR)

The Panel endorsed its request that:

FAO continue to inform ACMRR on its activities; a representative of the Panel be appointed as a member of ACMRR or, alternatively, attend its meetings as observer.

International Commission for the Conservation of Atlantic Tunas

The Panel took note of the present situation concerning the establishment of ICCAT, for which the Convention entered into force on 21 March 1969, and of the preparations for the First Session of ICCAT to be held in Rome from 1 to 6 December 1969 (EPFTR : 3/WP.10).

2. CONCLUSIONS AND RECOMMENDATIONS OF THE PANEL

Tuna Taxonomy

The Panel noted the report of the Working Party on Tuna Taxonomy (EPFTR : 3/WP.3) and was gratified to learn of the progress made in the collection of specimens at the main centre for the taxonomic study of tuna specimens at the U.S. National Museum in Washington D.C. Noting that specimens of certain species have not been received at the centre, the Panel recommended that the Convener of the Working Party on Tuna Taxonomy:

advise the secretariat of the Panel as to which specimens are still lacking in the collections so that the secretariat can in turn distribute a list of these species to all laboratories and museums of interest.

The Panel considered the comments of the Working Party on the scope and contents of a proposed monograph on scombroids, and noting their suggestion that a high calibre working manual intended mainly for commercial fishermen and fishery workers be prepared,

recommended to the Convener of the Working Party on Tuna Taxonomy that:

he arranges, in consultation with the secretariat, for the preparation of species identification sheets which could be published by FAO in the relevant series.

The Panel considered the question of a multi-disciplinary approach to taxonomic problems, and noting the comments of the Working Party on the advisability of selecting the bluefin tunas of the world as a suitable subject to commence this approach with, recommended that the Convener of the Working Party on Tuna Taxonomy:

further expands the Working Party on tuna taxonomy to include experts in the field of numerical taxonomy, parasitology and serology and biochemical taxonomy, as well as any other experts who may be vital to the success of a multi-disciplinary attack on the problem of bluefin taxonomy. The selection of such experts should be made in consultation between the Convener, the secretariat and the Chairman of the Panel.

During the discussions on tuna taxonomy, the Panel noted that some years have elapsed since the FAO Species Synopses on tunas were prepared for the World Scientific Meeting on the Biology of Tunas and Related Species, held in La Jolla in 1962 and since that time a great deal of information on the distribution, biology and ecology of tunas has been accumulated. The Panel therefore recommended:

the Chairman of the Panel, together with the secretariat, determine which Species Synopses are to be updated and then to invite certain experts to undertake this task. Preferably, those individuals having prepared the original synopses should be requested to update them.

Tuna Length Measurements and Tabulation

The Panel reviewed the report of the Working Party on Tuna Length Measurements and Tabulation (EPFTR : 3/WP.4). It was noted that a discrepancy exists between the recommendations made by the EPFTR Working Party and the General Fisheries Council for the Mediterranean (GFCM) for the maximum size interval in which data should be reported (EPFTR : 3/Inf.7). It was brought to the attention of the Panel that in some cases standard fork length as suggested in the report of the Working Party was not always used. To ensure greater comparability among data gathered in different areas the Panel strongly urged that:

(a) equations for the conversion of length measurements to standard fork length be included in any published works wherein lengths other than standard fork lengths are reported;

(b) every effort be made to utilize as far as possible one of the schemes suggested in the Working Party's report (Appendix 1), since these allow data to be readily re-grouped, and would allow for the easy comparison of data.

Tuna Eggs, Larvae and Juveniles

The Panel reviewed the report of the Working Party on Tuna Eggs, Larvae and Juveniles (EPFTR : 3/WP.5) and concluded that:

(a) the development of new and more efficient larval gear, than currently exists, be encouraged;

(b) but during the interim until such gear is developed the standard net proposed by the Working Party be employed whenever possible;

(c) the Working Party, through the Convener, coordinate their efforts in the development of gear for the collection of larvae, with the work of ACMRR;

(d) the Conveners of the Working Party on Taxonomy and the Working Party on Eggs, Larvae and Juveniles, decide among themselves through correspondence the minimum size of tunas, by species, that the former Party should include in their studies, and the maximum size of tuna, by species, that the latter should include in their studies in order that there will not be a gap in the size range of specimens studied.

The Panel noted with interest the work of the BCF Honolulu Laboratory, reported in EPFTR : 3/Inf.11, Appendix 5), and the development and use of the modified midwater trawl for the purpose of collecting juvenile tunas of a size that have been comparatively rare in the collections of fisheries museums, laboratories and institutions. The Panel commended the Honolulu Laboratory on the work and:

encouraged them to continue such investigations, as well as encouraged other research agencies to carry on such work whenever possible.

It was brought to the attention of the Panel that a Workshop on the Identification of Larval Tunas had been called by the BCF Honolulu Laboratory for March 1970 and it is hoped that all the experts who are currently actively engaged in this field will attend. The Panel requested the Director-General of FAO:

to provide the necessary support, if possible, for the attendance of one or two key scientists who may find it difficult to obtain support otherwise, to attend the Workshop.

Noting the need for the collection of live larval tunas for the purpose of studying colouration as an aid to identification, the Panel read with interest EPFTR : 3/Inf.10 which describes the Nakamura Larval Net which had been specifically designed to accomplish such collection (Appendix 2).

Development and Use of Underwater Sound in Tuna Research

The Panel read with interest the report of the Working Party on Underwater Sound (EPFTR : 3/WP.9), especially their outline suggested for future activity as indicated on page 3 of the report. Because of the nature of the problems and the utilization of underwater sound in fisheries research and because of the research of this nature currently going on for other fisheries, it was the opinion of the Panel that it would not be opportune to carry forward the suggestions of the Working Party at this time.

The Panel thanked the Working Party for its excellent work and disbanded it.

So that the Panel can be kept abreast of recent changes in the field of underwater sound it recommended that:

(a) *the secretariat of the Panel provide, with the help of the past Convener of the Working Party, Mr. H.S.H. Yuen (Honolulu), from time to time to the Panel members, a brief report of significant changes in the development and use of underwater sound gear for the identification and quantification of fish. The Secretary should take the necessary steps to invite Mr. Yuen's help;*
(b) *the FAO establish a directory of workers not only for tunas but for other species, who are actively engaged in the use of underwater sound for fisheries research.*

Subpopulation Identification by Genetic Techniques

The Panel listened to a report on the contributions presented at the ICES Conference in Dublin, on the identification of subpopulations of fishes by the use of serology and biochemical techniques and concluded that, although many of the methodological problems in this field have not been resolved, the use of this approach should be encouraged.

The Panel further:

(a) *reaffirmed the recommendations made in the report of the second session of the Panel held in Tokyo in August 1966;*
(b) *suggested that the name of Tuna Blood Group Centre in Hawaii should be changed to The Serological and Biochemical Centre for the Identification of Subpopulations of Tunas.*

The Panel noted with interest EPFTR : 3/WP.11 which included notes on genetic research in tuna as well as a list of people actively engaged in this field. The members of the Panel were asked to convey to the secretariat, by correspondence, any additions, deletions or corrections to this list, by 20 November 1969.

Tuna Tagging

Reviewing the contents of EPFTR : 3/Inf.9 which is a guide to the marks used for tunas as well as an inventory of tuna tagging programmes, the Panel noted some discrepancies in the contents and recommended that:

(a) *any suggestions for corrections should be addressed to the secretariat of the Panel prior to 20 November 1969;*
(b) *the final version of the Guide should be published and distributed by FAO as soon as practicable;*
(c) *additional information should be provided for the billfishes and published when complete;*
(d) *revisions to these guides should be prepared in the form of individual sheets and distributed about every 2 to 3 years.*

The Panel read with great interest the interim reports of the Working Parties on Tagging in the Pacific and Indian Oceans (EPFTR : 3/WP.6) and the Atlantic and Adjacent Seas (EPFTR : 3/WP.7) and made the following recommendations:

(a) *the Working Parties extend their studies to include the billfishes;*
(b) *when reporting tag return data in preliminary reports they be accompanied whenever possible with corresponding total catch data so as to provide some estimate of the expectation of tag returns;*

(c) additional research on the development of more efficient tuna tags. The Panel noted, however, the need to compare the efficiency of these newly developed tags with the standard plastic dart tag of the IATTC as recommended during the previous Panel session in Tokyo;

(d) the Working Parties, to the best of their ability, attempt to set up guidelines for the use of the most efficient type of tag of those currently available, for certain sized fish of a particular species captured by a specific type of gear;

(e) the amount of a tag reward be uniform within the country in which the tag is returned, regardless of where the tag was released, and further that the amount of the reward not be placed on the tag.

Noting the apparent relationship of the bluefin tuna in the Mediterranean Sea to those of the Atlantic, and the lack of tagging whilst they are in the Mediterranean, the Panel suggested that:

an accelerated tagging programme for bluefin tuna in the Mediterranean Sea would add much to the understanding of the population structure of this species in the Atlantic Ocean and to subsequent recommendations for the rational exploitation of that species.

To facilitate this the Panel, however, recommended that:

a freer exchange of ideas and correspondence, and a fuller collaboration between the Working Party on Mediterranean Scombroid Resources under the General Fisheries Council for the Mediterranean (GFCM) and the Working Party on Tuna Tagging in the Atlantic and Adjacent Seas take place, and that Dr. Rodriguez-Roda (Spain) continue to act as liaison between these two groups.

The Panel also recommended:

intensification of both bluefin and albacore tagging programmes in the northeastern Atlantic.

Furthermore the Panel agreed that:

Dr. J. Joseph be relieved as Convener of the Working Party on Tuna Tagging in the Pacific and Indian Oceans and be replaced by Dr. W. Bayliff of the IATTC.

Tuna Catch and Effort Statistics

The Panel reviewed in detail the statistical tables for tunas, bonitos, and skipjacks for 1967 prepared by the Fishery Statistics and Economic Data Branch of the FAO Department of Fisheries (EPFTR : 3/Inf.14). The Panel commended the Branch for the preparation of this report but noted discrepancies in the preliminary tables. The Panel reaffirmed the recommendations made during its first two sessions, requesting FAO:

to compile and publish on an annual basis, summarized data on total catches and catch and effort statistics

and further recommended that:

(a) *the Fishery Statistics and Economic Data Branch of the FAO Department of Fisheries be provided with additional support in terms of manpower and finance to carry out the recommendations of the Panel;*
(b) *some further consideration be given by this Branch to the standardization of common names of tunas for the purpose of reporting catch statistics;*
(c) *statistical coverage be expanded to include the billfishes, since these are generally taken on the same gear and in the same areas as tuna;*
(d) *Panel members carefully examine the statistical data presented in EPFTR: 3/Inf.14 and forward any corrections or suggestions to the Fishery Statistics and Economic Data Branch through the secretariat prior to 20 November 1969 so that the tables can be corrected prior to the First Session of the International Commission for the Conservation of Atlantic Tunas in December 1969;*
(e) *the members of the Panel provide the FAO Statistical Branch as soon as possible with whatever catch statistical data they might have for tuna fisheries of their respective countries which does not appear in the report;*
(f) *the members of the Panel generally act as a liaison between the Statistical Departments of their countries and the FAO Fishery Statistics and Economic Data Branch, in order to facilitate the completeness and accuracy of the statistical reporting of FAO.*

The Panel noted in EPFTR : 3/WP.12 six main difficulties in the collection and subsequent reporting of tuna catch statistics which are:

(a) inadequate breakdown of the catches according to principal species;
(b) incorrect identification of species;
(c) lack of conversion factors for both conversion from numbers of fish caught into weight (metric tons) and landed weight into live weight;
(d) inadequate indication of fishing areas;
(e) lack of information on types of gear used;
(f) under-counting or double-counting of tuna landings, if transhipment of raw and/or processed fish is made through foreign ports.

Realizing that the collection of effort statistics is quite difficult and that the subsequent compilation for analytical purposes is somewhat complex, the Panel suggested to FAO that:

the Fish Stock Evaluation Branch of the Department of Fisheries, in consultation with the Fishery Statistics and Economic Data Branch, examine the problems of collecting effort statistics for certain of the tuna fisheries of the world, and the ancillary problems related to the subsequent use of these data, and report back to the secretariat of the Panel their recommendations as to the magnitude and type of data required for stock assessment analysis and how it can be obtained.

Management of Tuna Resources

The Panel reviewed the report of the Group of Experts on Stock Assessment, dealing with the status of the stocks of yellowfin, bigeye, albacore and bluefin tuna in the oceans of the world and the effects of exploitation by man on their abundance (EPFTR : 3/WP.8). Also reviewed was the report on the present status of fisheries and assessment of potential resources of the Indian Ocean and adjacent seas which was prepared by a Group of Experts on the Indian Ocean under the Indo-Pacific Fisheries

Council (IPFC) in 1967 (EPFTR : 3/Inf.8). The Panel also listened to a report on the work of a Group of Experts established by the Indian Ocean Fishery Commission (IOFC) to assess in a more detailed manner and with more current information, the condition of the tuna stocks and other resources in the Indian Ocean. That Group met in Rome immediately prior to the Panel session.

The Panel agreed with the general conclusions of these reports, which indicated that in both the Indian and Atlantic Oceans, and probably the Pacific too, the longline fisheries for all species of tuna mentioned in the paragraph above, and some surface fisheries, are fully exploited, and that any increased effort will not result in the sustained increased catches but may indeed result in decreased catches.

The Panel:

(a) endorsed the conclusions and recommendations of the Working Parties;
(b) encouraged the implementation of some management programme for the fully or overexploited tuna fisheries referred to in the paragraphs above;
(c) suggested that management schemes such as fixing of fishing mortality by some form of catch quota, limited entry or some combination thereof be considered;
(d) urged FAO to circulate information to the various tuna fishing countries indicating the conclusions of the Group of Experts on Tuna Stock Assessment and the conclusions of the Panel and pointing to the necessity for implementation of a management programme if the stocks of tuna considered in the reports of the Working Parties are to be harvested at their present levels on a sustained basis;
(e) urged that consideration be given to the economic effects of over-capitalization.

Education, Training and Exchange of Workers

Realizing the truly international nature of tuna stocks, the benefits to the international community deriving from these stocks, and the importance of research to the subsequent rational exploitation of tunas which can derive from the exchange of research workers among laboratories engaged in tuna research, the Panel:

(a) stressed the need for support of such exchange and requested that the nations concerned with the tuna resources of the world, in collaboration with FAO, attempt to provide whenever possible such financial support as is necessary to accomplish such exchange;
(b) called attention to EPFTR: 3/Inf.11 and the exchange programme of the BCF Honolulu Laboratory and Japan and the Ryukyu's, and strongly encouraged the continuation of this programme and the establishment of such programmes among other laboratories;
(c) requested the members of the Panel to provide the secretariat of the Panel with information concerning exchange programmes within their respective laboratories so that the secretariat can in turn give this information wide circulation;
(d) noted that the International Marine Science publication of UNESCO/FAO is not complete and therefore expects Panel members to inform the secretariat of the Panel of cruises planned by their respective laboratories on which visitors can be accommodated with sufficient advance so that they can in turn publish notice of these cruises in International Marine Science.

Exchange of Publications

Having discussed in some detail the matter of publication exchange among the secretariat and the members of the Panel, the Panel suggested:

(a) each member of the Panel distribute to the secretariat and other Panel members a bibliography of publications on tuna research emanating from his laboratory; and

(b) that the secretariat in turn maintains as complete as possible a library of tuna publications at its office in Rome, which is to be kept as a permanent file to be passed on to subsequent secretaries of the Panel.

Review of Tuna Research

The possibility of preparing a review of tuna research as reported in the published literature was considered further by the Panel, but in view of intended works of a similar nature by scientists actively engaged in tuna research and which are expected to appear in the literature within a few years, the Panel:

decided to postpone the establishment of a Working Party to prepare a review of tuna research as appearing in the published literature.

Collaboration with other Bodies Concerned with Tuna Research and Management

Noting that there now exists a number of international bodies concerned with the investigation and rational management of tunas and that there is a need for freer exchange of information among the Panel and these bodies, the Panel recommended:

that when members of the Panel attend international meetings directly working in a field of interest to the Panel, they, after consultation with the Chairman and the secretariat, represent the Panel at these meetings and report on the work of the Panel as well as report back to the Panel the context of the meeting and when, in the opinion of the secretariat and the Chairman of the Panel, it is deemed particularly important that the Panel be represented at a particular international meeting, the FAO be asked to provide, if necessary, financial support of an individual to attend. This individual should be chosen by the secretariat and the Chairman.

Future Operation of the Panel

Noting that in many cases the same fisheries which capture tunas also take significant quantities of billfishes in the same areas at the same time, and realizing that the problems of research and management are similar for both groups, and noting further that there is at present no mechanism for international collaboration in the development of research on the billfishes of the world, the Panel extended its work to include these species and recommended that:

as membership of the Panel is renewed from time to time, the Director-General of FAO give consideration to the possibility of appointing as a member of the Panel a billfish expert.

The Panel having considered the importance of studies of baitfishes used for the capture of tunas, the need for information concerning various aspects of the behaviour of tuna and the need for a better understanding of the effect of ecological factors on the distribution and abundance of tunas, before these species can be managed in the most rational manner, therefore plans to take these matters under consideration in the future.

3 OTHER BUSINESS

At the closing of the Session, the Chairman of the Panel, on behalf of all members, expressed the appreciation of the excellent facilities provided and the generous hospitality shown by the Spanish authorities, in particular by the Escuela Oficial de Nautica y de Formación Profesional Nautico-Pesquera, the Instituto de Investigaciones Pesqueras and the Cámara de Comercio de Cádiz.

APPENDIX I

REPORT OF THE WORKING PARTY ON TUNA LENGTH MEASUREMENTS AND TABULATION

1. Introduction

The Working Party was set up in February 1965 as a subsidiary body of the FAO Experts Panel for the Facilitation of Tuna Research to investigate the matter of measurements and tabulations of total length of tunas, and to recommend a standard length interval and standard grouping for the reporting of such measurements for international compilation. The members were as follows:

Mr. J. Hamre	(Bergen)	(Convener)
Mr. L.K. Boerema*	(Rome)	
Mr. J.A. Gulland*	(Lowestoft)	
Dr. G.L. Kesteven*	(Cronulla)	
Dr. E. Postel	(Paris)	
Dr. A. Suda	(Kochi)	
Mr. R. Wilson	(Washington)	
Mr. E.B. Davidoff*	(La Jolla)	(part-time)
Dr. J.L. Kask	(La Jolla)	(part-time)

The Working Party carried out its work mainly by correspondence. Information collected by the members of the Working Party covered the measuring procedures carried out by virtually all laboratories concerned with tuna research (see Appendix). From this information, and views expressed in correspondence, there was considerable agreement on the methods to be used.

An interim report of the Working Party was considered by the Expert Panel during its Second Session in Tokyo in August 1966, and the Working Party was requested by the Panel to continue its work and to report to the Chairman of the Panel upon completion. Following discussions by correspondence, the final agreed report was forwarded to the Chairman of the Panel in July 1967.

2. Type of length measurements

All laboratories appear to be carrying out the recommendation of the Expert Panel that fork length should be used. Most use calipers, but some use measuring boards for suitable sizes of fish, and the Working Party agreed that measuring boards could be used where convenient. The Working Party recommends that only the metric system should be used for length and weight.

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* Presently working for FAO, Department of Fisheries

3. Size of length grouping

Though some laboratories measured with a precision of 1 mm, the smallest length grouping used was 1 cm. The Working Party therefore recommends that 1 cm groups should form the basis of reporting and tabulation. However, this grouping is clearly much too fine for larger fish. The Working Party felt that it should be easy to convert data from a finer to a coarser grouping, and therefore suggested that series of 1 cm, 2 cm, 4 cm or 8 cm groupings should be used. The numbers in each large group could then be obtained by adding the numbers in the appropriate pair of the next finer intervals, as shown in the following table:

Location of grouping	1 cm group		2 cm group		4 cm group		8 cm group	
	m	f	m	f	m	f	m	f
0 - 0.9	0.5	2	1	5	2	21	4	81
1 - 1.9	1.5	3						
2 - 2.9	2.5	6	3	16				
3 - 3.9	3.5	10						
4 - 4.9	4.5	16	5	34	6	60		
5 - 5.9	5.5	18						
6 - 6.9	6.5	14	7	26				
7 - 7.9	7.5	12						

m denotes midpoint of group; f the corresponding frequencies

No specific recommendation could be made concerning what particular grouping should be used in a specific instance; the optimum grouping will depend on the use to which the data are put and on the number of observations, as well as on the range and complexity of the length distribution. Two points should be noted. Firstly the use of more than about 20 groups adds to the work of tabulation etc. without adding significantly to the information supplied on such basic statistical characteristics as average length. Secondly as suggested by the ICES Newsletter Working Group, for studies of age distribution etc., the width of the grouping should be about half the standard deviation of the length distribution of fish of a given age. Little data on the latter was available to the Working Party, but that available suggested standard deviations of from 2 cm up to 10 cm for bluefin tuna depending on size, and from 4 cm to 9 cm for yellowfin. As a guide, the following groupings are suggested, based on the largest fish normally found in the samples:

Size of largest fish (cm)	<40	40 - 80	80 - 160	>160
Length grouping	1 cm	2 cm	4 cm	8 cm

4. Location of grouping

It was generally agreed that all sets of length intervals, whatever their extent, should start from zero, i.e. 1 cm groups should be from 0 - 0.99, 1.00 - 1.99 etc. Other locations of grouping intervals, e.g. for 1 cm groups recording to the nearest 1 cm, become clumsy when combining say 1 cm groups to give 2 cm groups. Thus while 1 cm groups recorded to the nearest cm run from 0.50 - 1.49, 1.50 - 2.49 etc., with midpoints 1 cm, 2 cm etc. the corresponding 2 cm groups run from 0.50 - 2.49, with midpoints 1.5 cm, 3.5 cm, etc. The Working Party therefore recommends that all measurements should be made to the unit below. This recommendation will make no practical difference to those at present measuring to the nearest mm, but some laboratories are recording to the nearest $\frac{1}{2}$ cm or cm, and should change their practice.

5. Specification of length interval

To avoid misunderstanding a common convention should be used in specifying the length interval. If a single figure is used by itself this should be the true midpoint of the interval. Misunderstandings will be best avoided by specifying precisely the limits of the interval, e.g. 2.0 - 3.9 cm, 4.0 - 5.9 cm etc. In tabulations this can sometimes be shortened by omitting the upper limit, i.e. 2.0-, 4.0- etc.; provided that the dash is included there should be no ambiguity as to the interval used.

Appendix

The following six tables on the procedure of measuring tunas and tabulating such measurements are based on information collected from 20 institutions engaged in tuna research. The data has been grouped according to variety with one table for each of the major varieties - bluefin, yellowfin, albacore, bigeye and skipjack, and one table for the tuna-like species of the genera Euthynnus, Sarda and Auxis.

The first columns of the tables show the length dimension measured. (A) denotes adults; (J) denotes juveniles. The second column indicates the instrument used for measuring the fish.

The third and fourth columns are concerned with the tabulation of tuna length statistics. The former shows the width of the length interval used, the latter specifies the actual upper and lower limits of the first interval on the length scale.

If, for instance, the specimens are measured to the nearest cm, and these data are grouped in nominal intervals of 30 - 34 cm, 35 - 39 cm etc., the actual size of the fish falling within these groups ranges from 29.5 to 34.4, 34.5 to 39.4 etc. The limits of the first interval on the length scale is in this case 4.5 to 9.4 cm. It should be noted that only in the case where the measurements are drawn to the limit below (mm, cm or the interval itself) does the tabulated data correspond to the actual size of the fish. When measurements are made to the nearest mm the discrepancy is negligible.

TUNA LENGTH MEASUREMENTS AND TABULATION

BLUEFIN TUNA

Length measured	Instrument	Unit of measurement	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length	caliper	nearest mm	1 cm	0.5 - 1.5	Calif. Fish and Game, U.S.
Fork length	tape	nearest inch	1 inch	0.5 - 1.5	Woods Hole Oceanographic Inst. U.S.
Fork length (A)	caliper	nearest cm	5 cm	4.5 - 9.5	Inst. of Marine Research, Norway
Fork length (A)	caliper	cm below	5 cm	0.0 - 5.0	Inst. für Küsten- und Binnenfish, Germany
Fork length (AJ)	caliper	nearest ½ cm	5 cm	4.75 - 9.75	Inst. de Invest. Pesq. Spain
Fork length	caliper	(A) cm above (J) mm above	(A) 2 cm and 4 cm (J) 1 mm		Nankai Reg. Fish Research Lab. Japan
Fork length (J)	caliper	nearest ½ cm	2 cm	1.75 - 3.75	Inst. des Pêches maritimes, Maroc
Fork length (J)	caliper	nearest cm	1 cm	0.5 - 1.5	CSIRO, Australia

TUNA LENGTH MEASUREMENTS AND TABULATION

YELLOWFIN TUNA

Length measured	Instrument	Unit of measurement	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length (AJ)	caliper	nearest mm	1 cm	0.0 - 1.0	Bur. Comm. Fish, Honolulu, U.S.
Fork length (A)	caliper	nearest mm	2 cm	0.0 - 2.0	Inter-Amer. Tropical Tuna Comm.
Fork length	caliper	nearest mm	1 cm	0.5 - 1.5	Calif. Fish and Game, U.S.
Fork length (A)	caliper	nearest mm	5 cm	2.5 - 7.5	Bur. Comm. Fish. Washington D.C., U.S.
Fork length	caliper	(A) cm above (A) / (J) mm above (J)	2 cm and 4 cm / 1 mm		Nankai Regional Fish. Research Lab. Japan
Fork length	caliper	nearest cm	5 cm	3.5 - 8.5	Fisheries Research Inst. Taiwan
Fork length	cal. + tape	nearest $\frac{1}{4}$ cm	5 cm	4.12 - 9.12	Fish. Research Station, Colombo, Ceylon
Fork length	m. board	nearest mm	5 cm	0.0 - 5.0	ORSTOM, Abidjan, Ivory Coast
Fork length	caliper	nearest $\frac{1}{2}$ cm	5 cm	4.75 - 9.75	Research Institute, Lagos, Nigeria
Fork length (A)	caliper	nearest $\frac{1}{2}$ cm	5 cm	4.75 - 9.75	EAMFRO, Zanzibar
Fork length (A)	m. board	nearest cm	1 cm	0.5 - 1.5	CSIRO, Australia
Fork length	caliper	$\frac{1}{2}$ cm below	1 cm or 5 cm		ORSTOM, France

TUNA LENGTH MEASUREMENTS AND TABULATION

BIGEYE

Length measured	Instrument	Unit of measurement	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length (AJ)	caliper	nearest mm	1 cm	0.0 - 1.0	Bur. Comm. Fish. Honolulu, U.S.
Fork length	caliper	nearest mm	1 cm	0.5 - 1.5	Calif. Fish and Game, U.S.
Fork length (A)	caliper	nearest mm	2 cm	0.0 - 2.0	Inter-American Tropical Tuna Comm.
Fork length	caliper	(A) cm above (J) mm above	(A) 2 cm or 4 cm (J) 1 mm		Nankai Reg. Fish. Research Lab. Japan
Fork length	caliper	nearest cm	5 cm	3.5 - 8.5	Fish. Research Inst. Taiwan
Fork length (A)	cal. + tape	nearest $\frac{1}{4}$ cm	5 cm	4.62 - 9.62	Fish. Research Station, Colombo, Ceylon
Fork length	caliper	$\frac{1}{2}$ cm below	1 cm or 5 cm		ORSTOM, France
Fork length	caliper	nearest mm	5 cm	0.0 - 5.0	ORSTOM, Abidjan, Ivory Coast

TUNA LENGTH MEASUREMENTS AND TABULATION

ALBACORE

Length measured	Instrument	Unit of measurements	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length (AJ)	caliper	nearest mm	1 cm	0.0 - 1.0	Bur. Comm. Fish. Honolulu, U.S.
Fork length	caliper	nearest mm	1 cm	0.5 - 1.5	Calif. Fish and Game, U.S.
Fork length	caliper	(A) cm above (J) mm above	(A) 1 cm (J) 1 mm		Nankai Reg. Fish. Research Lab. Japan
Fork length	caliper	½ cm below	1 cm or 5 cm		ORSTOM, France
Fork length	caliper	nearest mm	5 cm	0.0 - 5.0	ORSTOM, Abidjan, Ivory Coast
Fork length (AJ)	caliper	nearest ½ cm	2 cm	1.75 - 3.75	Inst. des Pêches Maritimes, Maroc
Fork length (A)	caliper	nearest ½ cm	5 cm	4.75 - 9.75	Research Inst. Lagos, Nigeria
Fork length (A)	caliper	nearest ½ cm	5 cm	4.75 - 9.75	EAMFRO, Zanzibar

TUNA LENGTH MEASUREMENTS AND TABULATION

SKIPJACK

Length measured	Instrument	Unit of measurements	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length (AJ)	caliper	nearest mm	1 cm	0.0 - 1.0	Bur. Comm. Fish. Honolulu, U.S.
Fork length (AJ)	caliper	nearest mm	1 cm	0.5 - 1.5	Calif. Fish and Game, U.S.
Fork length (A)	caliper	nearest mm	1 cm	0.0 - 1.0	Inter-Amer. Tropical Tuna Commission
Fork length (A)	caliper	nearest mm	5 cm	2.5 - 7.5	Bur. Comm. Fish. Washington D.C. U.S.
Fork length	tape	nearest inch	5 inches	3.5 - 8.5	Woods Hole Oceanographic Inst. U.S.
Fork length Body length*	caliper	(A) cm above (J) mm above	(A) 1 cm (J) 1 mm		Nankai Regional Fish. Research Inst. Japan
Body length*		mm	1 cm	0.0 - 1.0	Tohuku Reg. Fish Research Lab. Japan
Fork length	caliper	nearest mm	5 cm	0.0 - 5.0	ORSTOM, Abidjan, Ivory Coast
Fork length	caliper	½ cm or below	1 cm or 5 cm		ORSTOM, France
Fork length (J)	caliper	nearest ½ cm	2 cm	1.75 - 3.75	Institute des Pêches Maritimes, Maroc
Fork length (A)	m. board	nearest ½ cm	5 cm	4.75 - 9.75	Research Inst. Lagos, Nigeria
Fork length	caliper m. board	(A) nearest ½ cm (J) nearest mm	(A) 5 cm (J) 5 cm	4.75 - 9.75 0.0 - 5.0	EAMFRO, Zanzibar
Fork length (AJ)	m. board	nearest mm	1 cm	0.5 - 1.5	CSIRO, Australia

* Tip of snout to the posterior end of muscular knob on caudal fin base

TUNA LENGTH MEASUREMENTS AND TABULATION

OTHER TUNA-LIKE SPECIES

Length measured	Instrument	Unit of measurements	Size of grouping	Location of grouping	Laboratory, organization, country
Fork length	caliper	nearest ½ cm	3 cm 2 cm 1 cm	2.75 - 5.75 1.75 - 2.75 0.75 - 1.75	Inst. de Invest. Pesq. Spain
Fork length	caliper tape	nearest ½ cm	3 cm	2.87 - 5.87	Fish Research Station, Colombo, Ceylon
Fork length	caliper	nearest mm	0.5 cm 1 cm	0.0 - 0.5 0.0 - 1.0	Fish Laboratory, Haifa, Israel
Fork length	m. board	nearest mm	5 cm	0.0 - 5.0	ORSTOM, Abidjan, Ivory Coast
Fork length	caliper	nearest ½ cm	2 cm	1.75 - 3.75	Inst. des Pêches Maritimes, Maroc
Fork length	caliper	nearest ½ cm	5 cm	4.75 - 9.75	Research Inst. Lagos, Nigeria
Fork length	caliper	nearest ½ cm nearest mm	5 cm 5 cm	4.75 - 9.75 0.0 - 5.0	EAMFRO, Zanzibar

APPENDIX 2

REPORT OF THE WORKING PARTY ON TUNA EGGS, LARVAE AND JUVENILES

(with an attachment containing information on a larvae net from Japan)

1. The Working Party

The Working Party on Tuna Eggs, Larvae and Juveniles was originally set up as the Working Party on Methods of Collecting Larvae to select a standard plankton gear to collect tuna larvae. A report of the original Working Party was submitted to the Expert Panel for the Facilitation of Tuna Research and subsequently published as Appendix 5 to the Report of the Second Session of the Panel.

As a result of a recommendation adopted during the Second Session, the Working Party was requested to provide further information on equipment required for double oblique towing and to establish an ancillary standard surface tow for vessels not equipped for oblique towing. In addition, the Panel also recommended that a Working Party be formed to work on problems related to the development of keys for the identification of larvae and juveniles. The new Working Party as subsequently formed, was comprised of:

Mr. W.M. Matsumoto	(Honolulu)	(Convener)
Dr. S. Jones	(Mandapam Camp)	
Mr. W.L. Klawe	(La Jolla)	
Dr. W.J. Richards	(Miami)	
Dr. S. Ueyanagi	(Shimizu)	

Because of the similarity in the membership of this and the previous group, the two groups were combined into and designated as the Working Party on Tuna Eggs, Larvae and Juveniles.

This report includes (1) two amendments to the previous report, (2) additional information on the equipment required for double oblique towing and on an ancillary standard surface tow, and (3) a summary of current activities of the Working Party.

2. Amendments to Appendix 5, Report of the Second Session, Expert Panel

2.1 Subsequent to the publication of the Report of the Second Session, comments received by the Working Party pointed out that the netting material was usually sold in bolt width of 100 cm., and that if the cylindrical section of the net was made 100 cm long, sewing could be done along the selvage edge without wasting any material. Furthermore, the sewn edges would be stronger and the increased straining area would substantially reduce possible clogging when the net is towed in turbid waters.

In view of these advantages, the Working Party deems it appropriate to amend Recommendations Item 3-f-(1a) (p. 32) from 88 cm to 100 cm.

2.2 In the Working Party Report two mesh sizes (0.505 mm and 0.471 mm) were submitted as acceptable. Although the Working Party indicated its preference for the 0.505 mm mesh net, the final choice was left to the Panel to decide. Inasmuch as the Panel did not clearly state its choice, the Working Party feels that Recommendation Item 3-c be amended to read:

"c. Mesh aperture to be 0.505 mm,"

and that Item 3-f-(2) be deleted.

3. Equipment Required for Double Oblique Towing

Certain basic equipment are necessary for double oblique towing, but their requirements and capabilities need not be absolutely identical for all vessels. The primary concern is that the towing time, depth, distance covered, and volume of water filtered be comparable over all the vessels. The basic items and their minimum capabilities are listed below, together with descriptions of deck arrangements and specifications for net construction.

3.1 Gear Requirement

3.1.1 Deck winch. The winch should be equipped with a minimum of 500 m of wire and be capable of hauling in the net at any speed from 12 to 45 cm per second. If the winch is capable of hauling only at predetermined low and high speeds, the vessel speed should be adjusted so that the time required for the winch to retrieve the net will not be more than 15 minutes and the depth of tow will not be greater than the recommended 70 m. The diameter of the towing wire should be at least 0.5 cm.

3.1.2 Metering device. A metering device to monitor the amount of wire let out should be used. The device could be an independent unit, a metering block, or an integral part of the winch.

3.1.3 Plankton net. The net should be complete with net frame, net, codend, flowmeter, lead weight and all necessary bridles. The net frame may be made of solid stainless steel rod or galvanized pipe of appropriate diameter.

3.1.4 Angle indicator. An angle indicator should be used to measure the angle of stray of the towing wire. The indicator should permit readings to the nearest whole degree.

3.1.5 Angle versus wire length table. A table giving the necessary wire length at various wire angles should be readily available. For a 70 m depth oblique tow the lengths of wire required for various wire angles are given below:

Wire angle (deg.)	Wire out (m)	Wire angle (deg.)	Wire out (m)	Wire angle (deg.)	Wire out (m)	Wire angle (deg.)	Wire out (m)
44	97	54	119	64	159	74	254
46	100	56	125	66	172	76	289
48	105	58	132	68	187	78	337
50	109	60	140	70	204	80	403
52	114	62	149	72	227	82	503

3.1.6 Log form. The log form should include, in addition to tow identification and environmental data, spaces to record time, wire angle, amount of wire out, and remarks at 2-minute intervals during the entire tow (a sample log form is reproduced on page 23).

3.2 Net Specifications and Construction

3.2.1 Details of net. To facilitate in the fabrication of the net, complete details are presented. The specifications are based on nets previously fabricated by the Biological Laboratory, Honolulu (Figure 1 shows the dimensions of the various parts). Certain details such as the sewing of the seams, or the diameter of the codend, need not be followed exactly as given.

(i) Sections I, II and III are made of nylon monofilament screen cloth (Nitex or similar brand), I and II of mesh size 0.505 mm and III of 0.308 mm, respectively.

Section I is a cylinder constructed of a single piece of screen cloth cut 317.5 cm long at bolt width of 100 cm. The selvage edges are sewn to C-1 and C-2.

Section II is a cone constructed of screen cloth cut and sewn as shown in Figures 2 and 3.

Section III, the codend bag, is constructed of fine mesh screen cloth cut 25.8 x 33.3 cm as in Figure 4a. The screen cloth is folded over and the curved ends and the sides are sewn to form a bag.

(ii) C-1, C-2 and C-3 are made either of canvas or nylon cloth. If canvas is used, No. 10 canvas duck is recommended, with C-1 cut 36.2 x 317.5 cm and C-2 cut 23.1 x 317.5 cm. For C-3 and C-4, No. 12 canvas duck is recommended, with C-3 cut 13.0 x 34.3 cm and C-4 cut 10.4 x 34.3 cm. A 2.0 cm wide canvas strap, equipped with two 2.0 cm brass D-rings, is attached to C-4 (Figure 4b).

The forward end of C-1 is constructed as shown in Figure 5. To strengthen the leading edge, a 0.63 cm (diameter) nylon rope is sewn into the fold. Thirty brass grommets, 1.3 cm diameter opening, are spaced evenly (10.4 cm apart) along the forward end immediately behind the nylon rope insert.

SAMPLE DATA SHEET - PLANKTON NET TOW

Sheet___of___sheets

Vessel_____Cruise ____ Station No. _____ Tow No. _____

Local date _____ Time zone _____ BT slide No. _____

Position _____ Type of tow _____ Type of net _____

Depth of tow: Desired _____ Minimum _____ Maximum _____

Local time	Wire angle	Wire out (m)	Remarks

Meter No. _____

Start _____

End _____

Difference _____

Ship's course _____ Ship's speed _____

Surface temp. _____ Surface salinity _____

Wind direction ___ Wind velocity _____

Sea state (Beaufort) _____

Cloud cover (tenths) _____

Remarks _____

Duration (min.) : _____

Observer: _____

All cuts of both the screen cloth and canvas sections are made to allow 1.4 cm hems along the cut edges, and the seams are sewn as shown in Figure 6.

(iii) The net codend coupling may be made of any suitable material and design. Recently the Convener of the Working Party designed and built several couplings of polyvinylchloride (PVC) tubing (Figure 7) at a cost of about U.S. $0.30 each (cost of labour not included). The raised ends were made from the same tubing by cutting a ring 1.0 cm wide, which was cut through at one point so that it could be slipped over the edge of the tubing. A short piece of the same material was then fitted into the slot formed between the cut ends. These pieces were glued to the body of the coupling by a special PVC glue.

3.2.2 Attachment of hardware

(i) The flowmeter is attached to the net frame as shown in Figure 8. Any small gauge stainless steel wire and small brass or stainless steel turnbuckle of sufficient strength may be used.

(ii) The net bridle (Figure 9) may be of 0.5 cm stainless steel wire 71 cm long. A smaller gauge wire may be used, if it is strong enough, but the length should be as given. The loops at the ends may be either Nico-pressed or spliced.

(iii) A swivel of suitable size should be placed at the end of the towing wire ahead of the point where the lead weight is suspended (Figure 10).

(iv) The net may be attached to the net frame by a small but stout rope (recommended rope: 0.64 cm hard lay cotton or nylon) as shown in Figure 9.

4. Ancillary Standard Surface Tow

For vessels not equipped to take the standard 70 m double oblique tow, an ancillary surface tow, as described below, is recommended.

4.1 Net

The standard net should be used on all vessels, however, since the net need not be towed deep, the lead weight may be removed. For vessels not equipped with a suitable winch, or when tows are made without the use of a winch, the net may be towed from a fixed towing line at the side of the ship. In such instance a small weight should be used to keep the net submerged at all times.

4.2 Tow

The net should be towed at the regular towing speed of 2 to 3 knots for 30 minutes. The towing depth should be maintained at 1 to 3 m below the surface throughout the tow.

Towing times should be the same as for oblique towing.

5. Activities of the Working Party

The Working Party is concerned with the development of keys for the identification of eggs, larvae and juveniles. Before such keys can be developed, however, the identification of albacore and blackfin larvae need to be clarified. To achieve this the Working Party began to examine the value of red pigmentation on tuna larvae *in vivo* to investigate the usefulness of electrophoresis and to hatch and rear tuna larvae in aquaria.

5.1 Red Pigmentation

A partial analysis of red pigmentation data from about 300 tuna larvae was made at the Bureau of Commercial Fisheries Honolulu Laboratory. The species included yellowfin, albacore, bigeye, skipjack, frigate mackerel and bonito; however, only 5 larvae, provisionally identified as albacore, were available. The pigment patterns seemed to fall into three groups, as reported previously by Ueyanagi: skipjack, frigate mackerel and bonito in one group; yellowfin and bigeye in another; and albacore in a third group. Obviously, because of the grouping of several species, this may not be a species characteristic, but because of the probable distinction in patterns between albacore and yellowfin groups, it could be useful in separating these two species. More observations of albacore are necessary, as well as observations of several other species, including the Atlantic blackfin tuna.

Some Atlantic larval tuna material was examined at the Bureau of Commercial Fisheries Miami Laboratory, but it was felt that more specimens were necessary.

5.2 Electrophoresis

A preliminary electrophoretic study of adult tuna eye lens protein was made under contract for the Honolulu Laboratory. In the course of this study, a solution to extract soluble protein and albuminoid with the production of minimal "urea effects" in the electrophoretic patterns was found. Although this solvent was more effective than the commonly used solvents (i.e., distilled water and saline solutions) for extracting nuclear lens proteins, it still produced extracts that were too dilute when used on larval eye lenses.

Studies planned for the immediate future at the Honolulu Laboratory include the electrophoretic analyses of muscle tissues of both adults and juvenile tunas for subpopulation and species determinations.

Adult tissue analyses by electrophoresis are being done also at the Miami Laboratory.

5.3 Rearing Tuna Larvae

An aquarium for hatching fish eggs has been set up at the Miami Laboratory. Eggs of the little tuna, *Euthynnus alletteratus*, collected at the western edge of the Gulf Stream off Miami Beach, have been successfully hatched and the larvae reared through the yolk sac stage to about 6 mm total length. Prior to this, efforts to rear scombrid larvae have failed when the yolk sac was used up. In this experiment the larvae were reared to where they began to feed actively. Thus, the technique is now available to rear artificially

fertilized tuna eggs. Only the opportunity of fertilizing the eggs artificially has yet to present itself.

Artificial fertilization of yellowfin tuna eggs and subsequent rearing of the larvae are being attempted also at the Far Seas Fisheries Research Laboratory, Shimizu, Japan. The search for eggs and sperm from yellowfin tuna caught by purse seine off southern Japan is now in progress.

INFORMATION ON A LARVAE NET FROM JAPAN

During its Second Session the Panel of Experts for the Facilitation of Tuna Research passed a recommendation to request FAO "to distribute to the members of the Panel information on a larvae net at present being manufactured in Japan, to develop better apparatus suitable for various requirements".

Through the courtesy of Dr. Nakamura, information has been received from the manufacturer, Rigosha and Co. Ltd., 2 Kajicho 1-chome, Kanda, Chiyoda-ku, Tokyo, Japan, as follows:

"The Nakamura's Larva Net is a towing net for collecting larvae and plankton in medium layer. The net consists of a combination of two sleeve nets (the front), a sack-shaped net (the second), a net containing a funnel-shaped net with open end (the third) and Nakamura's collecting device (the rear). Each sleeve net is 10 m in length, the sack net 3 m in mouth width by approximately 6 m in length, and the third net 1.5 m in mouth diameter. Nakamura's device is 12.5 cm in mouth diameter and approximately 100 cm in length. The mesh of this net is No. GG54 (refer to Cat. No. 2535). It is made in a lantern-like shape in order to permit a better passage of water. The larvae, etc. are finally collected in this device. Nakamura's collecting device alone may be supplied, if desired".

The net can be ordered from the above manufacturer under Catalogue No. 2534 for a price of U.S. $530 (ex-factory price without packing and carriage). A drawing of the net is shown in Figure 11.

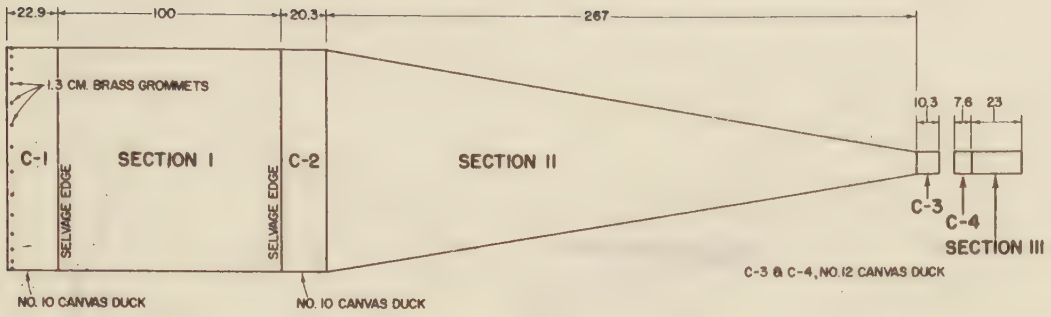

Fig. 1. Dimensions (in cm) of FAO standard net for tuna larvae.

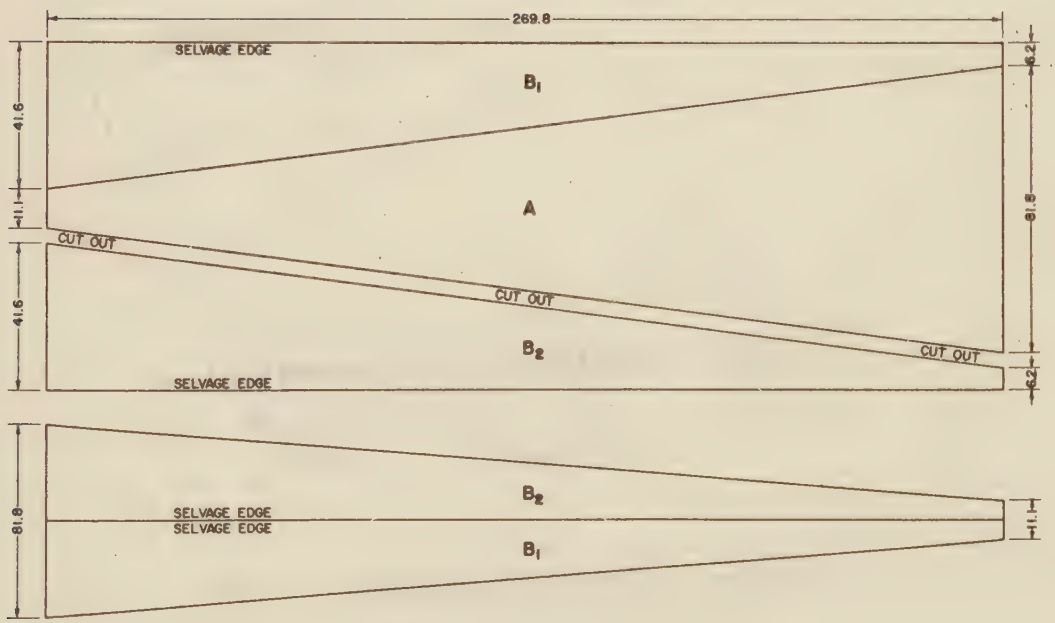

Fig. 2. Method of cutting screen cloth for Section II.

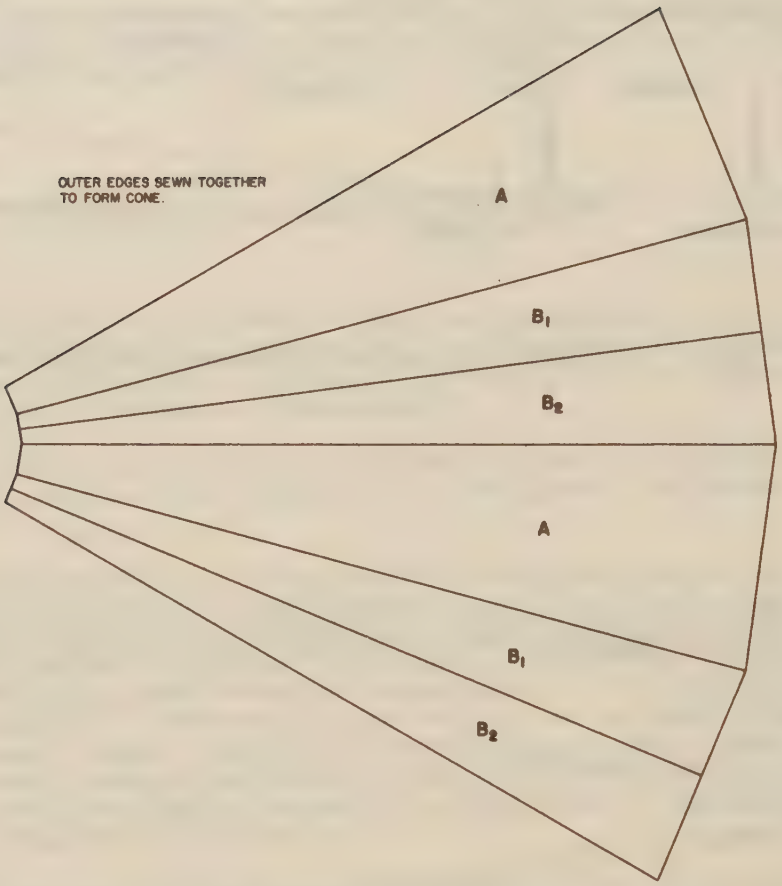

Fig. 3. Method of constructing Section II.

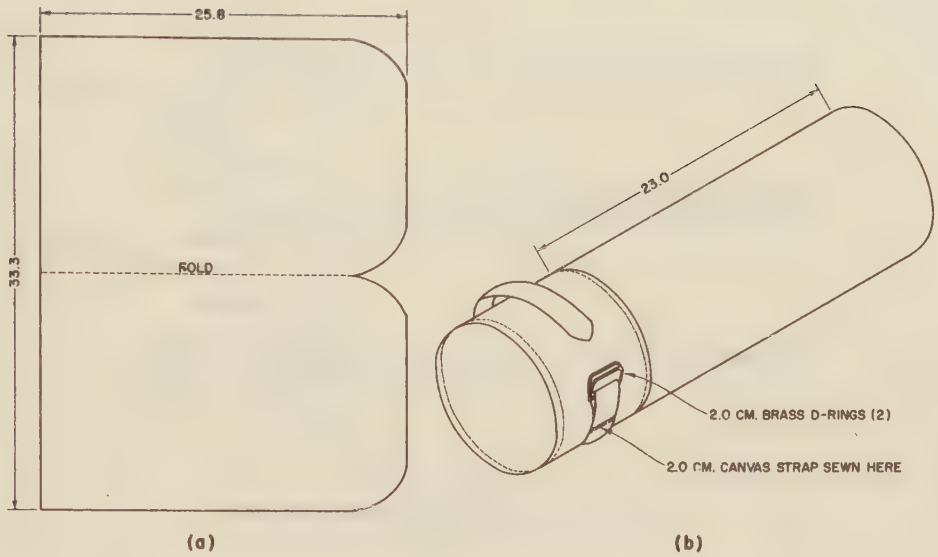

Fig. 4. Method of cutting screen cloth (a) and attaching strap (b) for Section III.

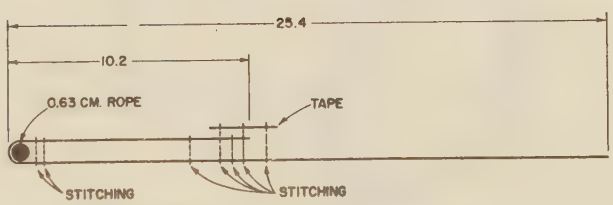

Fig. 5. Cross-section of forward end of C-1.

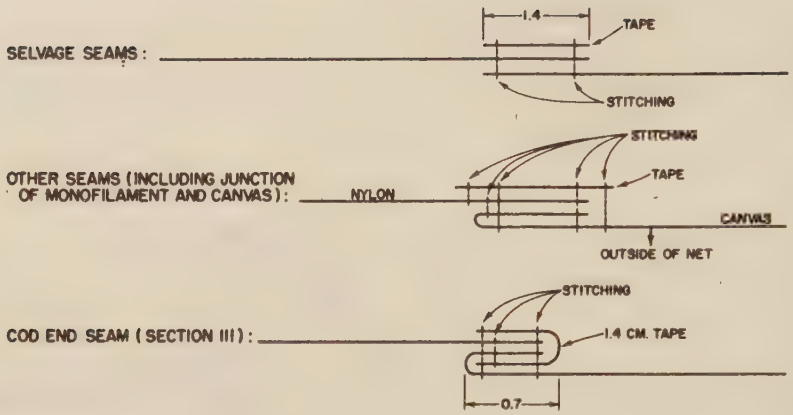

Fig. 6. Method of sewing seams.

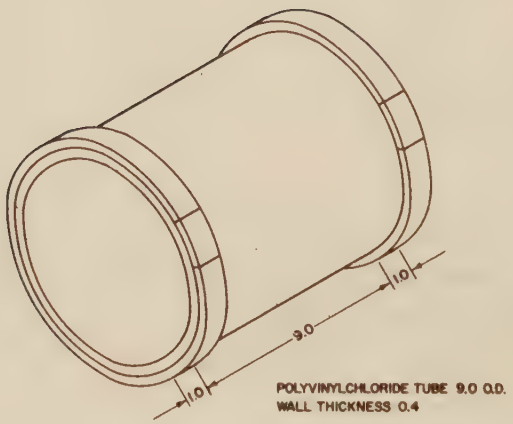

Fig. 7. Net-cod end coupling.

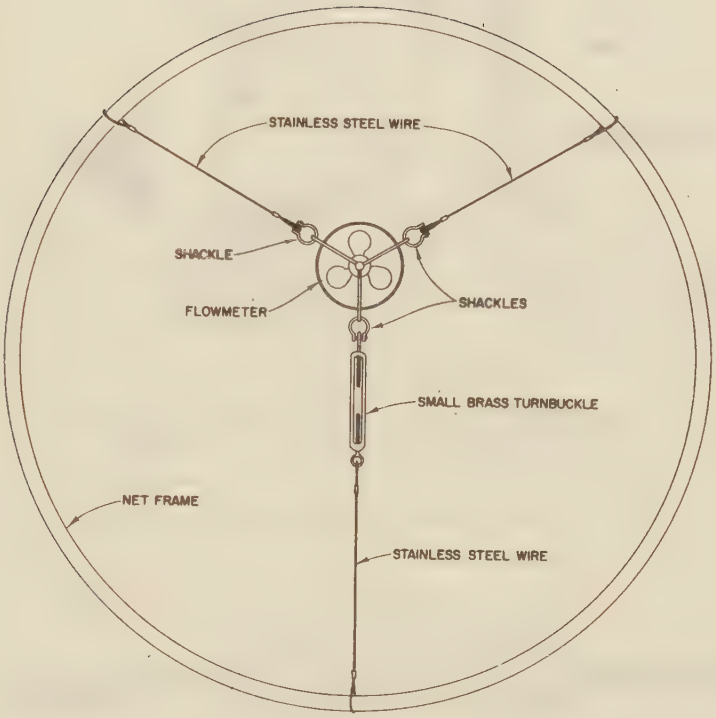

Fig. 8. Attachment of flowmeter.

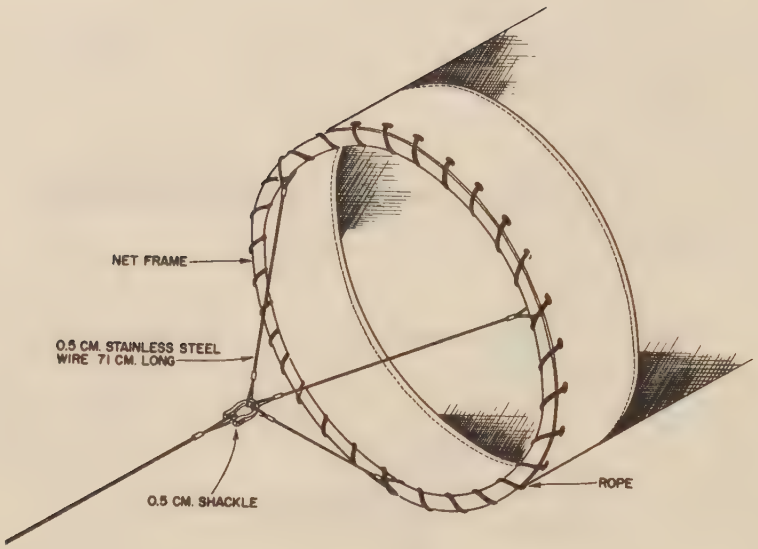

Fig. 9. Attachment of net and bridles to net frame.

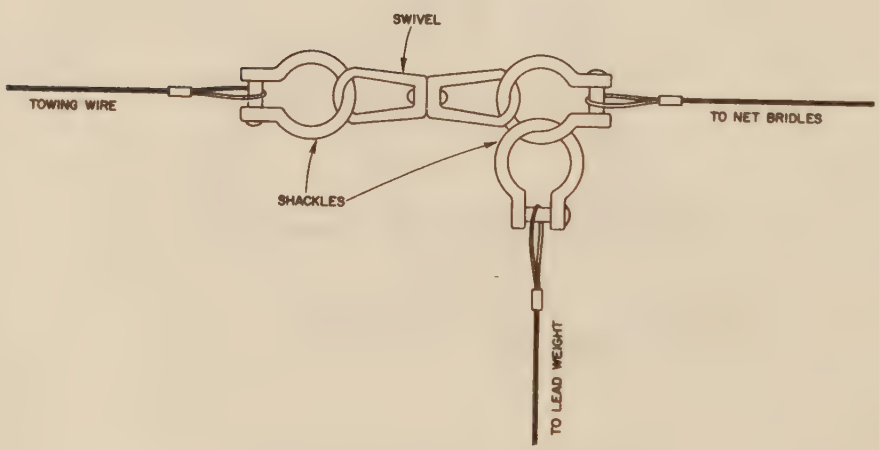

Fig. 10. Placement of swivel.

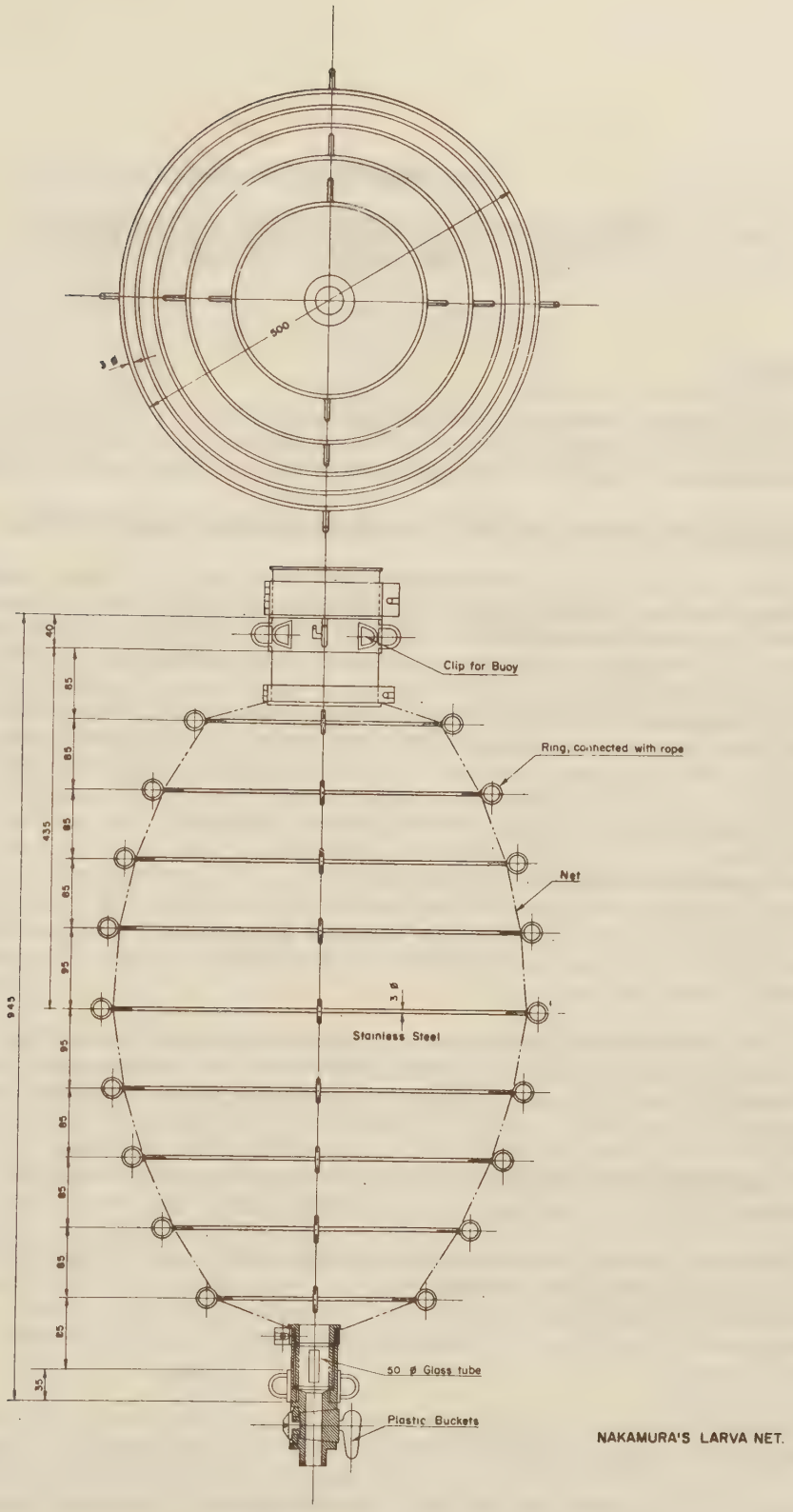

Fig. 11. Nakamura's Larva Net.

APPENDIX 3

INTERIM REPORT OF THE WORKING PARTY ON TUNA TAGGING IN THE PACIFIC AND INDIAN OCEANS

1. Introduction

During the Second Session of the FAO Expert Panel for the Facilitation of Tuna Research, held on 15-22 August 1966 in Tokyo, Japan, a group was formed to facilitate international cooperation in the tagging of tunas in the Pacific and Indian Oceans.

Quoting from the report of the Second Session of the Panel:

"The Panel reaffirms the recommendations made at its first session that priority should be given to conducting international tagging experiments on yellowfin tuna, skipjack, bluefin and albacore and stressed the importance of an organized information system on the tuna tagging programs conducted at various laboratories."

"The Panel reconsidered its previous suggestion to form a working group to exchange definite proposals in regard to this task, and decided to form two regional working groups, one for the Atlantic and adjacent seas and one for the Pacific and Indian Oceans." ..... "The Conveners were asked to select members for their groups, and report to the Chairman of the Panel in due course."

Terms of reference of the groups are:

(a) to record and follow up any tagging programme being carried out or planned and to inform the secretariat of the Expert Panel who could in turn give it wide distribution;

(b) to obtain the collaboration of those concerned with the tuna industry (private companies, fishermen, boatowners, fishmongers, canners, etc.) in securing the maximum returns of released tuna tags, with adequate recapture data;

(c) to actively encourage and develop tagging programmes and particularly to assist with arrangements for international collaboration in their execution.

In addition to establishing the terms of reference of the Working Party the Panel made the following recommendations:

(a) work to be confined to the yellowfin tuna, bluefin tuna, skipjack tuna and albacore; 1/

(b) research be initiated to determine the efficiency of different tags now in use;

(c) the plastic dart tag of the Inter-American Tropical Tuna Commission be used as standard for comparing other tuna tags.

1/ Although the Panel did not request that bigeye tuna be included in the species examined, we have discussed this species throughout the report.

The members of the Working Party are as follows:

Dr. J. Joseph	(U.S.A.)	(Convener)
Mr. J.S. Hynd	(Australia)	
Dr. S. Kikawa	(Japan)	
Mr. M. Legand	(New Caledonia)	
Dr. B.J. Rothschild	(U.S.A.)	
Dr. E.G. Silas	(India)	
Mr. P.T. Wilson	(Palau [U.S. Trust Territories])	
Mr. M. Yao	(Japan)	

The Working Party has carried out all of its work to date by correspondence.

2. The Uses of Tagging Experiments in Fisheries Science, with Particular Reference to Tunas

The use of tagging techniques to study tunas in the Pacific Ocean dates back to 1916 when Edward C. Johnston of the U.S. Bureau of Fisheries tagged albacore and yellowfin tuna in the eastern Pacific Ocean (Alverson and Chatwin 1964). The tags used were silver, circular shaped, bore the initials B.F. and a number, and were riveted to the fish's opercle or sub-opercle. Since that time large numbers of tuna have been marked and released. A review of such tagging, subsequent to 1950 will be given in a latter section of this paper.

Tagging experiments are generally conducted to provide information on mortality, growth and migrations of fish and to estimate population size. To facilitate ensuing discussions, a brief description of some of the types of information and theoretical considerations necessary for determining these parameters from tagging experiments is of value.

2.1 Mortality Rates

Consider a population of fish in the sea which is subjected to deaths from two major causes; those attributable to fishing and those due to causes other than fishing which are of a natural type. If the fishing is continuous and conducted at a somewhat constant level of intensity with gear fairly uniformly distributed on the fishing area, the survivors of a cohort of these fish can be considered to decline exponentially with time.

Given an initial population (N_o) of fish in the sea which is subject to a constant instantaneous fishing mortality rate of F and a constant instantaneous natural mortality rate of M operating simultaneously, the decline in their numbers can be expressed by the following differential equation:

$$\frac{dN}{dt} = -(F+M)N \qquad (1)$$

The number of fishes during the interval from t_o to t_1, which is Δ_1, can be expressed by integrating (1) to get

$$N_1 = N_o e^{-(F+M)\Delta_1} \qquad (2)$$

The rate of capture of fish from the initial N_o is expressed by

$$\frac{dY_t}{dt} = FN_t \qquad (3)$$

$$= FN_o e^{-(F+M)\Delta_1}$$

By integrating equation (3), the total number of individuals captured between time t_o and time t_1 is

$$Y_1 = \int_{t_o}^{t_1} FN_t dt$$

$$= N_o \frac{F}{F+M}(1-e^{-(F+M)\Delta_1}) \qquad (4)$$

Y is the total number of fish captured over the entire span of time and is expressed as the limit of Y_1 as $t_1 \rightarrow \infty$ and is equal to $(FN_o)/(F+M)$.

The exploitation rate E_1 during the interval Δ_1 which is the fraction of the total N_o at the beginning of the interval that was removed by fishing is

$$E_1 = \frac{Y_1}{N_o} = \frac{F}{F+M}(1-e^{(F+M)\Delta}) \qquad (5)$$

Now consider a population of tagged fish in the sea, for which we know T_o, the initial number tagged, and which follows the same survival curve as equation (2) above. Such a group of tagged individuals can be subjected to an initial mortality due to the immediate effects of the tagging operation. This is termed Type A loss by Ricker (1958) and Type 1 loss by Beverton and Holt (1957), and is herein expressed as $(1-\pi)$. Included in Type 1 loss are all losses which have the same effect as reducing the initial number of fish tagged such as non-reporting of recovered tags.

Tagged fish, unlike untagged fish, may suffer an additional continuous mortality due to the effects of tagging. This is termed Type 2 loss by Beverton and Holt and Type B loss by Ricker and is herein expressed as an instantaneous rate Q. This instantaneous rate Q can be broken into two components. The first, G, which is continuous instantaneous rate of mortality due to the effects of carrying a tag, and (L), the instantaneous rate of loss due to tag-shedding.

Employing these concepts then, it can readily be seen from (4) that of an initial T_o tagged fish released, the number of individuals recovered from time t_o to t_1, is

$$r_1 = \pi T_o \frac{F}{F+M+Q}(1-e^{-(F+M+Q)\Delta_1}) \qquad (6)$$

Equation (6) can be manipulated mathematically in a number of different ways in order to estimate rates of natural and fishing mortality. Of course, before these rates can be estimated in any experiment it is necessary that the effects of Type 1 and 2 errors be corrected for. This is especially true if comparisons are to be made of the results from tagging experiments of different investigators who might use different methods of capturing the fish to be tagged, varying methods of handling the fish during tagging and different tag types. In this light, then, there is an obvious advantage in standardization of tag types and tagging methodology as well as experiments to estimate $\underline{1-\pi}$, $\underline{G}$ and $\underline{L}$ ($\underline{G}$ and $\underline{L}$ need not, for most purposes, be estimated separately).

In addition to estimating mortality rates, tagging data is extremely useful for (1) estimating the growth characteristics of fish and (2) providing information relative to migration and rates of dispersal and making estimates of population numbers or biomass.

2.2 Growth Rates

To estimate growth from tagging data it is necessary to record information on the size at release of the tagged members of the population, their size at recovery and the length of time that they were at liberty. In this respect it is extremely important that experiments are designed which provide information over the entire size range of the fish being studied. In many cases growth is often somewhat inhibited due to the effects of tagging; consequently, growth estimated from tagging is useful only as a first estimate of growth or as a rough verification of growth estimated by other means such as size frequencies, marks on hard parts, etc. Of course, if tagging experiments could be designed which allow for estimating the effect that carrying a tag has upon the natural growth of the animals then such estimates of growth would be accurate.

Growth can be estimated in a number of different ways. An estimate of the average change in length for a given interval of time at liberty can be computed by merely computing the regression of change in length (Δl) on time at liberty (Δt). A description of this technique is given by Schaefer, Chatwin and Broadhead (1961). More sophisticated techniques wherein estimates (i) of the parameters of the von Bertalanffy growth function as derived from tagging data are given in Fabens (1965) or (ii) the parameters of a general growth curve which describes a family of curves, as derived from tagging data, are given by Joseph and Calkins (1969).

2.3 Migrations and Dispersal

For studies of movements and dispersal it is necessary to record the time and place of tag releases and the time and place at which these releases are recovered.

2.4 General

Before conducting tagging experiments it of course, goes without saying that the problems to be solved through tagging need to be well thought out and well defined. Some effort must be made to determine whether or not the factors to be estimated through tagging are indeed estimable and if so

at what cost. The design of tagging experiments are certainly as important or more important than the tagging itself. Very little is available in the published literature on experimental design of tagging programmes.

Tagging experiments can generally be considered to fall into two categories. In the first category is the situation where no previous tagging has been done and virtually nothing or very little is known concerning the biology, behaviour and dynamics of the stocks of fish under study. In this situation tagging on an opportunistic basis (releasing tags whenever and wherever possible) is of value. In the second category, wherein something is known of the stocks of fish under study, from other sources and from the results of opportunistic tagging, then carefully designed tagging experiments are needed to acquire more precise information concerning these stocks. Even in the first case, however, distributing the tags widely in space, time and over different sizes of fish has obvious advantages, both in providing more reliable first estimates of the various aspects of behaviour and mortality, and in providing a better basis of subsequent more carefully designed experiments.

In designing such studies the seasonal movements of the fish in the fishery and the spatiotemporal distribution of the fishing vessels needs to be considered. The problem of design is of such complexity that simple tagging models so far available appear inadequate for its solution. At this point it is of value to comment on work which is being conducted at the Inter-American Tropical Tuna Commission, under the guidance of Dr. Jerome Pella, which is directed toward the development of simulation models which should prove useful in the design of tagging experiments which can inexpensively be examined in the laboratory before employing them in the field at great expense. It is anticipated that by examining a variety of experiments by use of the simulator, one can be found which will provide the data needed at minimal cost, and just as importantly, will enable the avoidance of tagging programmes which would have little chance of providing the information sought to the requisite degree of precision.

The simulator, in the form of a digital computer programme designated SIMTAG, permits the release of a group of tags from any coordinate point of a map of the eastern Pacific whereafter the tagged fish move in an unpredictable manner over the map, yet on the average show distinct patterns of movement depending on the season of the year and the location in the ocean. The simulator generates such movement for each individual of the release until it is caught, it dies or the tag is lost, or the time of the experiment has expired.

Simultaneously with the generation of movement histories, survival histories are generated. The fish or tags are subject to seven types of loss or mortality-various types of tag shedding, various types of mortality imposed on the fish as a result of being tagged, constant and seasonal natural mortality, and fishing mortality. Fishing mortality is realistically represented as varying spatiotemporally analogously to the distribution of fishing effort observed in the actual fishery. When a tag is lost from one of the seven causes, SIMTAG records the time, locality, and cause of the loss. Later, after the experiment is completed, this information is printed out in a series of tables.

The Commission's staff is now in the process of choosing movement and mortality parameters for SIMTAG which cause SIMTAG to mimic reasonably well results of past tagging studies. Once these are determined, it is possible to begin experimenting with various designs and methods of analysis to find some combination which will work well in the actual fishery.

The work of the Commission in this respect is of importance in that SIMTAG can be modified and extended to apply to any particular fishery of single or multiple species. The use of such approaches to design tagging experiments is encouraged, but it is emphasized that the model is no better than the parameters fed into it.

3. A Review of Tagging Experiments Already Completed

It is of importance to review briefly tagging experiments previously conducted in the Pacific and Indian Oceans, to note where possible, the purpose and extent of the experiments, the results by way of estimates of migratory patterns and mortality and growth rates, and to cite the references wherein these works are discussed.

3.1 Albacore

Albacore tagging commenced in the Pacific Ocean during 1952 when the California Department of Fish and Game, Bureau of Commercial Fisheries, Oregon Fish Commission and the Washington Department of Fisheries released 220 tagged fish during the period July through September in the eastern North Pacific Ocean.*) Tagging has been continued in nearly every year since then. A total of about 6616 tagged albacore were released during the period 1952 through 1967. Of these about 141 were recovered. The purpose of this tagging was to provide direct information concerning the relationships of albacore taken in the eastern north Pacific to those taken in the surface fishery off Japan and the sub-surface longline fishery in the central Pacific, to study migrations within the northeastern Pacific and to estimate growth rates, (Shomura and Otsu 1956; Otsu and Uchida 1963; Otsu 1960; Graham 1957 and 1959; Clemens 1961 and 1955; Gansele and Clemens 1953; Blunt 1954).

Additional tagging of albacore has been done by the Fisheries Agency of Japan. During 1956 a cooperative tagging programme, between the Fisheries Agency (Mie Pref. Fish. Exper. Station) and the Bureau of Commercial Fisheries Biological Laboratory in Honolulu, to tag albacore was carried out. There were released 270 tagged albacore. None of these were recovered. During 1957 and 1958 an additional 943 tagged albacore were released. Of these, 10 were recovered. The purpose of this tagging was to establish the inter-relationships among longline caught albacore in the north western Pacific (Mie Exp. Fish Sta. 1957; Suda 1960 and 1962.

3.1.1 Migrations and population structure. Most of the tag recovery information available on albacore tuna has been examined by biologists concerned with the fisheries for this species. This information has been extremely useful in studies dealing with the population structure of albacore of the North Pacific Ocean and has been examined in some

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*) Some earlier, but unsuccessful tagging was accomplished during 1949 and 1950 off British Columbia (Partlo, 1951).

detail by Clemens (1961), Otsu (1960), Otsu and Uchida (1963) and Suda (1962). The most notable information resulting from these tag recoveries was the establishment of transpacific movements of albacore from California to Japan. From these experiments it is assumed that albacore of the north Pacific are a single stock.

3.1.2 Growth. Information on size at release, size at recovery and time at liberty is available on some of the tagged albacore recovered during recent years. This information has been utilized to estimate growth rates and asymptotic size (Otsu 1960 and Clemens 1961). Though the derived curves appear to give reasonable estimates of the rate of growth, they do not define size at age.

3.1.3 Mortality rates. No estimates of mortality rates have been made for albacore tuna utilizing the tagging data discussed above. This is due to the scantiness of the tagging coverage.

3.2 Yellowfin Tuna

Following Godsil's (1938) unsuccessful experiments, the first substantial yellowfin tuna tagging in the eastern Pacific was commenced in the early 1950's by the California Department of Fish and Game. Between 1952 and 1959, 13,213 yellowfin were tagged and released. Of these, 263 were recovered. The purpose of this tagging was to define the population structure of the yellowfin tuna supporting the fishery in the eastern Pacific Ocean (Blunt and Messersmith, 1960 and Wilson 1953).

Scientists of the Inter-American Tropical Tuna Commission commenced tagging during 1955. From that date, through 1964 they released 46,412 tagged yellowfin and of these there were returned 8,135 tagged fish. The Commission's programme was designed primarily to yield information on the migrations and population structure of the tropical tunas in the eastern Pacific Ocean and secondarily to provide estimates of their growth and mortality. A number of reports which deal with the analyses of these tagging data have been published (Schaefer, Chatwin and Broadhead 1961; Fink 1965; Chapman, Fink and Bennett 1965; Joseph et al, 1964; and Fink, in press).

Since 1957 the Japanese have tagged about 2,130 yellowfin tuna. Of these 40 were recovered. Most of the recoveries were from fish caught and tagged by using pole and line, hand line and trolling gear. About 635 fish were tagged in this manner, all in the western Pacific between about 140-145°W and 10-40°N. Of the 1,496 fish caught by longline gear and tagged, only two were recovered. The purpose of the tagging by the Japanese Fisheries Agency was to study migrations of yellowfin tuna. Information on these tagging experiments is available in Suda (1961 and 1966).

3.2.1 Migrations and population structure. In the eastern Pacific Ocean the migration of yellowfin tuna as inferred from tagging data, has been studied quite extensively (Blunt and Messersmith 1960; Schaefer, Chatwin and Broadhead, 1961; Joseph, et al 1964; Fink 1965, and Fink, in press). General conclusions were that (i) yellowfin tuna do not migrate great distances as do the albacore, bluefin and skipjack (ii) there is no substantial movement of yellowfin from the eastern Pacific into waters to the westward and (iii) within the eastern Pacific there is neither complete mixing of the stocks of yellowfin nor is there real isolation of any groups.

Sufficient tagging data is not available to allow comment on the migrations or population structure of yellowfin in the central and western Pacific, nor the Indian Ocean.

3.2.2 Growth. Estimates of the growth of yellowfin tuna in the eastern Pacific have been made by using information on the size at release, size at recovery and interval of time free from the recovery of tagged fish (Blunt and Messersmith 1960, and Schaefer, Chatwin and Broadhead 1961). Neither of these studies described growth in terms of mathematical models but merely presented estimates of change in length at varying intervals of time at liberty.

There was not enough tagging data from the central and western Pacific and the Indian Ocean to warrant estimates of growth rate.

3.2.3 Mortality. In the eastern Pacific tagging data was used to make preliminary estimates of mortality rates for yellowfin tuna. Schaefer, Chatwin and Broadhead (1961), estimate survival rates (s) for yellowfin tuna in the northern and southern areas of the fishery separately using the method of Jackson (Ricker 1958). In a more detailed study using additional data Fink (1965) estimated total mortality (Z), fishing mortality (F) and catchability coefficient (q) using the methods of Gulland (1963). In a subsequent paper, Chapman, Fink and Bennett (1965) estimated the instantaneous rate of shedding of tags (Q) from yellowfin tuna using data from single and double tagging experiments.

No such estimates have been made for the central or western Pacific nor for the Indian Ocean.

3.3 Bigeye Tuna

Very little information is available in the literature describing tagging experiments conducted on bigeye tuna. In the Japanese literature it is reported that between 1957 and 1965 about 2,245 tagged bigeye were released in the Pacific and Indian Oceans (Suda 1961 and 1966). Of these, 2,081 were fish captured by longline and there are no reports of any of these being recovered. The remaining 164 bigeye tagged and released were captured by pole and line, handline and trolling. Of these releases, 16 fish were recovered. Information relating the movements of these tagged fish is not available in the published literature.

In the eastern Pacific 371 bigeye tuna were tagged during 1958 and 1967 by personnel of the Tuna Commission incidental to the tagging of yellowfin and skipjack tuna. Of these, 9 tagged fish were recovered; 8 were recovered in the area of tagging and one had moved eastward a distance of about 600 miles.

Estimates of mortality and growth have not been made for bigeye tuna using tagging information.

3.4 Skipjack Tuna

Of all the tuna tagged in the Pacific Ocean the majority has been skipjack. From 1952 to 1964 a total of about 110,000 skipjack were tagged and of these 5,680 were recovered.

Of the Japanese releases, 11 recoveries were made and these are summarized in the Progress Report of the Mie Prefectural Fishery Experimental Station, March 1965. All of the releases and recoveries were made within 500 miles of the mainland of Japan.

Of the approximately 13,000 skipjack released in the area of the Hawaiian Islands by the personnel of the Bureau of Commercial Fisheries Hawaiian Laboratory there were approximately 1,300 tagged fish recovered. The purpose of this tagging was to estimate rates of movement of the fish through the Hawaiian fishery, growth and population structure. In addition to tagging around the Hawaiian Islands, about 4,600 skipjack were tagged and released in the area of the Marquesas and Tuamoto Islands, none of these were recovered (Brock and Marr 1960, and Anonymous 1958).

In the eastern Pacific Ocean 90,408 skipjack were released and of these there were 4,369 recovered. Of this total the California Department of Fish and Game released 14,265 from 1952 - 1959. There were 237 of these recovered (Blunt and Messersmith 1960). The purpose of this tagging was to elucidate the population structure of the skipjack tuna supporting the fishery in the eastern tropical Pacific.

From the period 1955 through 1964 the Inter-American Tropical Tuna Commission tagged and released 76,143 skipjack and of these 4,132 were recovered. The purpose of this tagging was to yield information on the migrations and population structure of the skipjack tuna and to provide estimates of their growth and mortality. A number of reports which deal with the analyses of these tagging data have been published (Schaefer, Chatwin and Broadhead 1961; Fink 1965; and Joseph and Calkins 1969).

3.4.1 Migrations and population structure. The tagging experiments conducted by the Japanese were primarily centred in the waters to the east of the island of Honshu. Most releases were made during the summer months in the area 145-150°E and 35-40°N. Of the 11 recoveries the general pattern of movement was northward to about 45°N thence south near the area of release. None of these fish were at liberty for more than a year and none were returned from areas outside the area of the home island fishery.

Returns from the tagging experiments conducted in the Hawaiian Islands showed considerable inter-island movement but did not provide any information concerning the movements of skipjack when they left the area of the islands.

Tag recoveries from fish released in the eastern Pacific Ocean have been analyzed in some detail by a number of workers (Blunt and Messersmith 1960; Schaefer, Chatwin and Broadhead 1961; Rothschild 1965; Fink 1965; Fink in press; and Joseph and Calkins 1969). These analyses show primarily the intra-seasonal movement of skipjack within the area of the eastern Pacific. Notable in these tagging data is the recovery of four skipjack in the central Pacific which were tagged in the eastern Pacific. Three of these recoveries were made in the area of the Hawaiian Islands and one in the Line Islands.

No tagging data are available for the Indian Ocean.

3.4.2 Growth. Estimates of growth rates using tag release information are not available for the western Pacific nor for the Indian Ocean.

In the central Pacific Rothschild (1966) utilized all the available data for which there was information on size at release, size at recovery and interval of time at liberty to estimate the growth of skipjack tuna. He utilized 74 observations and computed the parameters for the von Bertalanffy growth function. However, because size at age data were not available to Rothschild he could only assign arbitrary ages to the skipjack.

In the eastern Pacific Schaefer, Chatwin and Broadhead (1961) estimated the average change in length per month for skipjack tuna as determined from tagging data. Subsequently, Joseph and Calkins (1969) utilized about 450 observations from tagged tuna to estimate the parameters of a number of different growth functions. As was the case with the work of Rothschild in the central Pacific, they could not ascribe an absolute age scale to the growth curve.

3.4.3 Mortality rates. Estimates of mortality rate utilizing tag recovery information from the western and central Pacific are not available.

In the eastern Pacific Schaefer, Chatwin and Broadhead (1961) estimated survival (s) rates for skipjack tuna using the Jackson method. Subsequently Fink (1965) using additional data and employing the methods of Gulland, estimated the rates of natural mortality (M) fishing mortality (F) and the catchability coefficient (q).

In a more recent paper Joseph and Calkins (1969) reanalyzed the data of Fink and some additional data not analyzed by Fink, using a variety of mathematical models. They made estimates for various areas of the fishery and for different years of the instantaneous rates of natural mortality, fishing mortality and the catchability coefficient.

3.5 Bluefin Tuna

In the eastern Pacific Ocean the first northern bluefin tuna (Thunnus thynnus) tagged and released were by personnel of the California Department of Fish and Game who released 64 bluefin from 1953 through 1956. In 1958 staff ot the Inter-American Tropical Tuna Commission tagged and released 121 bluefin incidental to tagging yellowfin and skipjack tuna (Orange and Fink 1963; Chatwin and Orange 1960). From 1962 through 1966 personnel of the U.S. Bureau of Commercial Fisheries in conjunction with personnel of the California Department of Fish and Game tagged and released 2,800 bluefin tuna. Of these 556 tags were returned. A detailed list of all tag releases and recoveries is given by Bell (1968) and Clemens and Flittner (1969).

In the western Pacific Suda (1966) notes that during the period 1963-1965, 636 northern bluefin tuna (Thunnus thynnus) were tagged in the area between 34-40°N and 139-142°E. Of these 636 releases there were recorded 22 recoveries.

In the southwestern Pacific Ocean 38,566 southern bluefin (Thunnus maccoyii) have been tagged by CSIRO during the period 1959-1968. Of these 2,189 had been recovered by the end of 1968. Of this total 9,279 were released in eastern Australia, 6,420 in south Australia and 22,867 in western Australia (CSIRO 1967).

3.5.1 Migrations and population structure. Of the recoveries of fish from releases in the eastern Pacific, seven northern bluefin crossed the Pacific and were recaptured close to Japan. The remaining recoveries were all from waters within the eastern Pacific and had been at liberty up to three years.

Of the fish tagged and released in Japan, two were recovered in the California fishery, again showing trans-Pacific migration. The remaining recoveries were in the area of the Japanese home island fishery.

Of the 2,189 southern bluefin recovered, Japanese longliners returned 78 from off the south and east coasts of Australia, 8 east of New Zealand, 27 from the south-central and south-east Indian Ocean and 6 south of Africa. The remainder were recovered in the inshore Australian fishery. These data confirm that Pacific and Indian Ocean southern bluefin are one stock (Hynd 1969).

3.5.2 Growth. Information on growth rates of northern bluefin as derived from tagging data are not available in the literature. Growth rates of southern bluefin computed from tagging data correspond well with results obtained using the Peterson method.

3.5.3 Mortality rates. Estimates of mortality rates for bluefin tuna in the northern Pacific utilizing tagging data have not been made.

For the southern bluefin estimates of fishing mortality (F) and natural mortality (M) have been made. The latter estimate is biased in that emigration could not be separated. From the results of double tagging experiments estimates have also been made of tag loss through shedding.

4. Current Tagging Programmes and Objectives

A list of the current tagging programmes underway in the Pacific and Indian Oceans is given in some detail by Akyüz (1966). By way of review these are by area and species as follows:

4.1 Indian Ocean

There are no published records concerning tuna tagging programmes in the Indian Ocean; however, during 1968 the East African Marine Fisheries Organization tagged and released 14 yellowfin tuna in waters off Kenya.

4.2 Pacific Ocean

4.2.1 Japan.

(a) Mie Prefectural Fishery Experimental Station

Year-round tuna tagging from commercial vessels in the Japan Sea and the western portions of the Mariana Islands. Species to be tagged are albacore and skipjack. The subject matter to be studied is mixing, dispersal and migration.

(b) Tohoku Regional Fisheries Research Laboratory

Year-round skipjack tagging from commercial vessels in the Japan and Philippine Sea to study migrations.

4.2.2 Australia. Bluefin tuna tagging in the waters of eastern and southern Australia by CSIRO, Division of Fisheries and Oceanography. The purposes of this programme are to estimate population size and mortality rates as well as migration and stock structure.

4.2.3 U.S.A. The California Department of Fish and Game is conducting a bluefin and albacore tuna tagging programme in the northeastern Pacific Ocean to study migration patterns of bluefin tuna and to estimate growth and mortality rates. Tagging is confined to the sea area within 200 miles of the coast between about 40°N and 25°S.

The State of Oregon Fish Commission is also conducting tuna tagging experiments in the area from 40 to 120 miles off their coastline. These experiments are designed to study migration of fish into and out of the Oregon fishery as well as to provide data to further refine estimate of growth.

4.2.4 Inter-American Tropical Tuna Commission. At the present time the tagging programme of the Tuna Commission is confined to the release of marked fish from commercial fishing vessels as opportunity affords. The species being studied in this programme are yellowfin and skipjack. The purpose of this tagging is to study the relationship of fish caught in the inshore areas to those taken further offshore and to establish the relationship between yellowfin tuna captured in the surface fishery to those captured in the longline fishery.

5. Consideration for the Facilitation of International Cooperation for Tuna Tagging

5.1 The Working Party on tuna tagging recommends that the following points be considered by the Panel of Experts for the Facilitation of Tuna Research during future discussions and plans for tuna tagging in the Indian and Pacific Ocean:

(a) that the FAO continue, with the help of the Working Party, to record and follow up any tagging programme being planned or carried out in the area of interest, so that the secretariat of the Panel could give the relevant information a wide distribution;

(b) that the Working Party on Tuna Tagging be asked to continue its existence in order that its members might aid in the dissemination and collection within their own countries of tag release and tag recovery information so as to ensure that the maximum number of returns of released tuna are made with adequate recapture data;

(c) that a universally agreed to amount be established for tag return rewards;

(d) that the FAO assist with arrangements for international collaboration in tagging cruises to the extent that they might wish to assist countries planning tagging cruises into territorial waters of other nations in securing permission to operate in the waters of the latter. For example, a country A may want to tag tuna in the international waters adjacent to

country B, but in order to do so A may find it necessary to capture bait or to fish for tuna within the territorial waters of B. Since on some occasions it may be difficult for A to procure permission from B, assistance from FAO would be of value. A possible way in which FAO would provide this assistance would be for it to certify the vessel from which country A planned to do the tagging as a research vessel which is to be used for the purpose of tagging and request of country B that such vessel be allowed certain freedoms in its scientific pursuits;

(e) so that tagging experiments among different research agencies will be more comparable, double tagging experiments be encouraged in order to standardize against the standard dart-type tag used by the Tuna Commission, and to better establish shedding rates of both types of tags for all species of tuna;

(f) the design and execution of tagging experiments to compute estimate of initial tagging mortality ($I-\pi$) should be encouraged. Such rates can be estimated by 1) conducting holding experiments in very large holding pens such as the shore side traps used in Japan and the Philippines or holding tanks such as used by the Bureau of Fisheries in Honolulu, or 2) by designing experiments which allow the estimation of π in equation 5 above (for details see Joseph and Calkins 1969);

(g) that the exchange of personnel, techniques and equipment among various research agencies be encouraged in order to derive the maximum benefit from previous experience in tuna tagging.

5.2 After reviewing the accomplishments of past tagging experiments and present knowledge of the dynamics and population structure of tunas in the Pacific and Indian Oceans it is the general opinion of the group that the following problems of pressing importance can be at least partially solved through tagging experiments which the international community of research agencies is technologically capable of accomplishing at the present time.

5.2.1 The relationship of small tuna of a particular species, during their first year in the fishery, to larger fish of the same species that contribute to the same or other fisheries. For example:

(a) Establishing the relationship between small yellowfin caught in surface fisheries in the western Pacific and larger yellowfin caught in the longline fishery in the central and western Pacific;

(b) The relationship of small albacore in the Japanese home island fishery to larger albacore caught in the surface fishery in the north eastern Pacific Ocean. Continued emphasis on the relation of surface albacore of the northeastern Pacific to the surface and subsurface albacore of the western and central Pacific;

(c) The relationship of first year recruits in the surface bluefin fishery in the Sea of Japan to subsequent recruitment in the surface fishery in the eastern Pacific Ocean;

(d) The relationship of surface-caught small bigeye tuna in the eastern and western Pacific Ocean to the large bigeye tuna taken on longline gear;

(e) The relationship of longline caught yellowfin tuna in the eastern Pacific to longline caught yellowfin throughout the entire Pacific Ocean;

(f) The relationship between surface-caught albacore off Chile and longline caught albacore in the southcentral and southeastern Pacific Ocean;

(g) The relationship between surface-caught southern bluefin in southern Australia and longline caught southern bluefin in the Indian and South Atlantic Oceans.

5.2.2 Since skipjack tuna appear to be one of the underexploited tuna resources of the Pacific and Indian Oceans it is of importance eventually to arrive at some estimate of what the potential yield from these stocks might be, and when this potential yield is attained to have the necessary information to ensure their rational exploitation. One of the very important requisite bits of information necessary to accomplish either of these tasks is knowledge concerning the population structure of the species. The group considers tagging to be a useful tool to obtain such knowledge to the degree that it will establish the physical (not genetic) relationship of skipjack to each other, in different areas of the ocean. Of importance in this respect would be tagging experiments in the area of the Bonin, Palau and Mariana Islands, the Ryukyu and Philippine Islands, and New Guinea, also in the Line, Society, and Marquesas Islands, and the offshore island areas in the eastern Pacific, as well as near Hawaii.

5.3 It is abundantly clear from previous knowledge on tag returns and from the present status of fisheries for tunas that the tuna resources of the world are truly international common property resources. The animals themselves certainly travel great distances within the oceans of the world and indeed may very likely even travel between oceans. If maximum returns are to be expected from research efforts and funds being expended on tuna tagging programmes then it will be necessary to coordinate efforts among national and international research agencies.

With this in mind then it is important that this Working Party or some similar type group, be continued and that it serve the purpose of aiding in the coordination of international tagging programmes designed to provide information concerning specific problems relating to tunas. This can be to the extent of coordinating the joint planning and execution of tagging experiments wherein physical and fiscal resources are pooled to solve problems of common concern and to ensure that the maximum benefits to the international community are derived from such experiments.

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APPENDIX 4

INTERIM REPORT OF WORKING PARTY ON TUNA TAGGING IN THE ATLANTIC AND ADJACENT SEAS

Introduction

During the Second Session of the Expert Panel for the Facilitation of Tuna Research in Tokyo, August 1966, the Panel recommended the formation of two regional Working Parties for Tuna Tagging, one for the Pacific and Indian Oceans and one for the Atlantic and Adjacent Seas.

It was proposed that priority should be given to international tagging experiments on yellowfin tuna, skipjack, bluefin and albacore, and both Working Parties were established with the following terms of reference:

1. To record and follow up any tagging program being carried out or planned, and inform the Secretary of the Panel, who will give the information wide distribution.

2. To obtain the collaboration of those concerned with the tuna industry (private companies, fishermen, boat owners, fishmongers, canners, etc.) to secure the maximum returns of released tuna tags with adequate recapture data.

3. To encourage actively and develop tagging programs, and particularly to assist with arrangements for international collaboration in their execution.

The formation of the Working Party on Tuna Tagging in the Atlantic and Adjacent Seas with members from a considerable number of countries around the Atlantic (see document EPFTR: 3/Inf./2(g)) took, unavoidably, rather a long time. It was, therefore, only recently that the group started their work. Instead of Dr. Postel (France) who was originally invited by the Panel to act as the Convener of this group, Mr. F.J. Mather III, (U.S.A.), kindly agreed to work in that capacity.

In view of the existence of a Working Party on Mediterranean Scombroid Resources under the General Fisheries Council for the Mediterranean (GFCM) which is *inter alia* concerned with tuna investigations, it was decided to leave that area, at least for the time being, out of the consideration. However, Dr. Rodriguez-Roda (Spain) who is a member of both the Working Parties was invited to act as a liaison officer between the two groups.

As the Working Party has only recently commenced the work, it was agreed to concentrate first on item 1 of the above-mentioned terms of reference. This interim report gives a brief summary of the tuna tagging experiments which have been carried out so far in the Atlantic, and of some of the results. The summary is followed by more detailed outlines on relevant activities in a number of countries, as far as these could be made available within a short time. It is intended that the Working Party will further elaborate this review and start their work also on the other items of their terms of reference.

Summary

According to the information available so far, 14,787 tunas have been tagged in the Atlantic by eight nations (Table 1). These totals are exclusive of Mediterranean taggings. The Atlantic totals include 10,446 releases of bluefin tuna, 2,186 of skipjack, 872 of yellowfin and 1,209 of albacore, and 1,936 returns from bluefin and 89 from skipjack, 4 from yellowfin and 20 from albacore.

The greatest progress has been made with bluefin tuna, but even for this species, much remains to be done. Population identity has not been established, and irregular migratory patterns, or interchanges between stocks, are suggested. The regional distribution of tagging has been uneven. Tagging of small bluefin in the Bay of Biscay is especially important, but it is also desirable to tag these fish in any other areas where they are found, such as the Mediterranean and its Atlantic approaches, and the tropical waters off the Americas. The marking of large individuals is costly but important, and should be extended to the South Atlantic.

Very little has been learned about the other species, but in view of the heavy pressure on yellowfin and albacore stocks, and the apparent potential of skipjack, it is important to correct this condition. Tagging in the Gulf of Guinea area should be especially interesting.

Table 1.

Summary of Atlantic tagging programmes, by nations and species.
Returns are before slash, and releases are after slash.

Nation	Bluefin	Skipjack	Yellowfin	Albacore	Mixed
Canada	49/544	4/115	3/388		3/60*
France	1/14	0/34		20/1006	
Japan			0/68	0/150	
Norway	27/237				
Portugal	0/24				
South Africa					0/14
Spain	19/312				
United States	1840/9315	85/2073	1/416	0/53	
Totals	1936/10,446	89/2186	4/872	20/1209	3/74
Grand Totals	2052/14,787				

*Bluefin and skipjack. The returns were from bluefin.

Argentina

There are at present no plans for the tagging of the four tuna species mainly considered in this paper.

However, tagging experiments with bonito (Sarda sarda) were started in 1968 by the UNDP/Special Fund Fishery Development Project, executed by FAO in collaboration with the Argentinian Government. Altogether, 803 tagged fish were released in the shelf waters between 35°S and 38°S latitude. The "Spaghetti" type of tag was used, and so far only one recovery has been made.

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Canada

Canadian tuna tagging effort can be considered under three main categories (Table 2): inshore, longline, and purse-seine. The sustained programme has been on inshore bluefin tuna, mainly in St. Margarets Bay, Nova Scotia, where fish have been marked and released from fish traps since 1963, and in SE Newfoundland where tagging by sports fishermen was initiated in 1968. Small numbers of bluefin and yellowfin captures on pelagic longlines have been tagged since 1966 in an area extending from the Caribbean to the Flemish Cap. Purse-seine releases of yellowfin, bluefin, and skipjack have been made on an opportunity basis. Some tagging of the latter two species was carried out during the last two of the three years (1963-65) in which Canadian purse-seiners fished tuna off New Jersey and Long Island. These boats subsequently remained in Canadian waters fishing herring. Purse-seine releases of yellowfin and skipjack have been made in the Gulf of Guinea (1967), and in the Pacific in the Bay of Guayaquil (1968).

All programmes are continuing with marking large bluefin from the Nova Scotia traps and the Newfoundland sports fishery, the only ones planned for 1969. Longline releases will be made when fish are available during swordfish cruises, and purse-seined fish will be tagged when the opportunity arises.

Tag types in current use are similar to WHOI types M and H. The plastic barb F.T. 1A type tag is not suitable for tagging large fish by harpoon and has a poor return rate compared to the type C in experiments in which different fish in the same release were marked with one or the other (see Table 3). Some double tagging with different tags in the same fish have only yielded three returns, all of which were marked with capsule and "C" tags. Two fish recovered a year after release retained the capsule tags while the third, recaptured only 5 days after release, retained only the "C" tag, but the capsule tag was seen before the fish (540 lb) was hauled over the side of the boat. Two fish double tagged with "C's" each lost one tag, one being recaptured after 1 day and the other after 374 days.

The trans-Atlantic movement of one small bluefin released off New York and recaptured in the Bay of Biscay has been reported (Mather et al., 1967), while the only other returns of note are those of two large bluefin released from the Nova Scotia traps and recaptured the following year off Cape Cod. These fish provided the first such evidence of mixing between the two areas. No further returns have been reported despite increased numbers of releases.

Table 2. FRB (St. Andrews) Tuna Tagging Summary; releases and (returns) showing tag type used.

Species	Programme	1963	1964	1965	1966	1967	1968	Total
Bluefin	Giant	13C	6C	9C	2C	35C(1C)		248(11)
	Nova Scotia	5F		34CC(2C)	6A	148A(4A)		
				9AC(1C)	63CA(2A)	3AA(1AA)		
						3AC		
						4CC		
	Newfoundland						24A	24(0)
	Longline		1CC	6C	2CA	1C	2AB	18(0)
			1P	1A	1AA	2CC.		
				1CP				
	Purse seine (small)		18C(4)	68C(14)				254(38)
				168F(20)				
Yellowfin	Longline		1P		4C	3C		10(0)
						1CC		
						1A		
	Purse seine					58F	20C	422(4)
						320A(3)	12A(1)	
							12B	
Skipjack	Purse seine		72C(3)	6C		30A(1)	7B	124(4)
						7F	2C	
Skipjack/ Bluefin	Purse seine			60F(3)				60(3)

Tag types: C = WHOI type "C"; F = Floy FT1A (as WHOI "D"); P= Floy FM60 (as WHOI "E"); A = capsule (as WHOI "M"); B = spaghetti and monofilament (as WHOI "H"); two letters indicate double tagging.

Table 3. FRB Tuna Tagging (West Atlantic purse-seine fishery).

	Releases			Returns				
Year	Bluefin	Mixed bluefin/ skipjack	Skipjack	1964	1965	1966	1967	1968
1964	18		72	2skj	4 bf			
					1skj			
1965	168F(20)	60F(3 bf)	6		16F bf	4F bf	3F bf	*
	68C(14)				5C bf	6C bf	3C bf	

*1 unconfirmed report

FRB (St. Andrews) Tuna Tags

Tag type	Dart type	WHOI equivalent	FRB series
Spaghetti	Stainless steel	C	301-500; 03001-04000
F.T.1A	Single barb plastic	D	101-300; 01001-01500
FM60 & 61	Double barb plastic	E	501-700; 02001-02500
Capsule	S.S.	M	A1001-3000
Spaghetti & monofilament	S.S.	H	B01001-02000

France

The tuna tagging programme in France, mainly carried out by the Institut Scientifique et Technique des Pêches Maritimes (ISTPM), is primarily concerned with one species, the albacore (Germo alalunga), but some bluefin tuna and skipjack have been tagged as well.

In July/August 1960, 400 albacore were marked with dorsal loop tags in the Bay of Biscay from the vessel ROSELYS (Letaconnoux, 1961, 1963). One of these was recaptured locally in the same season, and two were recaptured in the Bay of Biscay in the following season. The latter returns showed that the same fish returned to the Bay year after year.

In September 1967, 90 albacore were marked in the Bay of Biscay with Floy FT-1 (standard IATTC) tags, and eight of these were recaptured in the same season (Allain, 1968). The returns showed generally eastward and southward migrations within the Bay of Biscay. The return rate of nearly ten percent indicates a considerable impact of the fishing on the stock.

A campaign of marking albacore, bluefin tuna and skipjack tuna was carried out in the 1968 season with the ISTPM vessels THALASSA and La PELAGIA in the Bay of Biscay and nearby parts of the eastern North Atlantic, 18 May - 5 July and 19 August - 30 September. 516 albacore, 14 bluefin and 34 skipjack were marked with Floy FT-1 (WHOI type D, standard IATTC tag) and Floy FM-67 (WHOI type H) tags. Some of these tags carried WHOI legends, and some ISTPM. In that season, 9 albacore and 1 bluefin were recaptured, giving some indication of the local movements of the former.

In 1969 taggings of albacore are being carried out by ISTPM with the vessel La PELAGIA during the period 5 June - 30 October, in the area between 37°N and 51°N, latitude and between the continental shelf and 20°W longitude (off western Portugal, Bay of Biscay and SW Ireland). The tags used are the Floy FT-1 (the standard IATTC tag) and Floy FM-67 (the WHOI type H).

Table 4.

Summary of French tuna tagging, by species and years.
Returns are before slash, and releases are after slash.

	Bluefin	Skipjack	Albacore
1960			3/400
1967			8/90
1968	1/14	0/34	9/516
Totals	1/14	0/34	20/1,006

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Germany (Federal Republic)

No fishes of the species in question have been marked satisfactorily, and the absence of bluefin tuna from the North Sea since 1962 has forced the postponement of planned programmes.

Japan

150 albacore, 48 bigeye tuna and 68 yellowfin tuna have been tagged from Japanese Atlantic longline vessels in the years 1957-1968 (Table 5), but no returns have been recorded to date.

Table 5.

Number of tunas tagged and released in the Atlantic Ocean by Japanese longline vessels since 1957

Year	Albacore	Bigeye	Yellowfin	Blue marlin	White marlin
1957		1	28	1	1
1965	44	11	14	1	
1966	9	29	16		
1968	97	7	10		
Total	150	48	68	2	1

Areas at large

1957	1N - 3N, 2W - 16E
1965	27S - 19N, 8W - 44W
1966	35S - 47N, 16E - 47W
1968	29S - 16N, 14E - 76W

Norway

237 bluefin tuna were marked in Norwegian waters in the years 1957 through 1962, and 27 returns have resulted (Table 6). These were large individuals marked from purse-seine catches in the vicinity of Bergen. Lea hydrostatic tags attached to miniature harpoons (darts) were used. In the unsuccessful 1957 experiments, the darts were made of stainless steel. Subsequently, the darts were made of Akulon, a plastic material (Hamre, 1960, 1961). The most significant results were the five recaptures of Norwegian fish in traps in the vicinity of Cadiz, Spain, showing that the Norwegian purse-seine fishery and the trap fisheries in the Atlantic approaches to the Mediterranean depend, at least partly, on the same stock. The Norwegian Lea hydrostatic tag has demonstrated very good durability and general effectiveness.

TABLE 6.

Releases and returns for bluefin tuna marked in Norwegian waters, by year of release and year and area* of recapture.

Releases		Returns								Totals
Year	Number	1959	1960	1961	1962	1963	1965	1966	1967	
1957	22									
1958	18	1N,3S								4
1959	42	4N,1A	2N,1S	2N						10
1960	62		1N	4N	1S					6
1961	80			3N	2N	1N	1S	1N	1N	9
1962	13						1N			1
Totals	237	5N, 1A, 3S	3N,1S	9N	2N,1S	1N	1S,1N	1N	1N	30

*N = Norwegian waters
A = Arnholt (Kattegat)
S = Spain

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Portugal

24 small bluefin tuna of about 5 kg each were tagged between 19 and 25 September 1968 on the Portugese west coast 40 miles off Cabo Raso. Norwegian Lea hydrostatic tags were used, with the numbers 362-384 and 386. No returns have been reported so far.

South Africa

Four cruises were undertaken between December 1963 and August 1964 to mark tunas with THE IATTC tag, but only 14 fish were tagged and no returns resulted.

Spain

Tagging experiments on bluefin tuna (Thunnus thynnus (L.)) were started in 1960 in the Gulf of Cadiz (Barbate and Santi-Petri) in order to study the migrations of these fishes, and in particular the immigration into the Mediterranean Sea through the Straits of Gibraltar. The experiments were continued until 1967 with the exception of 1964 and 1966 when no programmes could be carried out. Also 1968 and 1969 were years when no taggings were made because of low abundance of fish.

During the six years of investigations a total of 312 bluefin tuna were tagged and released, and 19 of these fishes were recaptured (see Table 7). While most of the recaptures were made in the Gulf of Cadiz, off southern Portugal and near the Straits of Gibraltar, thus indicating local movements, 4 of the tagged tunas were recaptured in the Mediterranean Sea: 2 near the Straits of Gibraltar and one each on the southern coasts of Spain (near Cartagena) and France (near Marseille). Two further recaptures off Tripoli (Libya) were reported verbally but the tags were unfortunately not returned, so that these results remain uncertain. One of the tagged tunas was recaptured by purse-seine in the Atlantic off the Moroccan coast near Mogador.

Three of the tunas recaptured in the Mediterranean Sea had been tagged during the pre-spawning phase and only one during the postspawning phase. In general there is, however, evidence to show that tunas tagged during the postspawning phase have a better chance to survive.

The time interval between tagging and recapture was generally longer for the tunas recaptured in the Atlantic than for those which immigrated into the Mediterranean. In two cases this period was 1 year and 10 months, in three cases, 10 months, and in the remainder, between 1 day and 3 months.

In conclusion, there can be no doubt that bluefin tunas immigrate through the Straits of Gibraltar into the Mediterranean Sea. The low percentage of recaptures in that area seem to indicate, however, that the rate of immigration is not very high. Further experiments are required with a larger number of taggings, to investigate this in more detail.

TABLE 7.

Year	No.of tunas tagged	Type* of tag used	Mean size (cm)	Recaptures** 1960	1961	1962	1965	1967	Total No. of tunas recaptured	Percentages of recaptures
1960	37	NHTA*	159	2S,1P, 1Sm,1Fm	1P, 1M	2M			9	24.3
1961	100	THEN	164		2S,1P 1C	1S			5	5.0
1962	51	THEN	187			2P,1M			3	5.9
1963	24	THEM	199						0	0
1965	50	THEM	219				1P		1	2.0
1967	50	THEM FM-60						1Sm	1	2.0
	312			2S,1P, 1Sm,1Fm	2S,2P, 1M,1C	3M,1S, 2P	1P	1Sm	19	6.1

*NHTA = Norwegian Lea Hydrostatic Tag with Akulon dart;
THEN = Spanish Hydrostatic Tag with Nylon dart;
THEM = Spanish Hydrostatic Tag with Metal dart;
FM-60 = Floy Tag : Double Barbed Nylon dart and Vinel tube.
** S = Atlantic waters off Spain; Sm = Mediterranean waters off Spain;
P = Portuguese waters; M = Atlantic waters off Morocco;
C = Waters off Ceuta; Fm = Mediterranean waters off France.

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United States of America

Although small scale experiments in 1941 yielded promising results, effective tagging of tunas off the Atlantic coast of the United States did not begin until 1954. In the 1941 experiments, 23 small bluefin tuna were marked off Long Island, New York, with celluloid disc, by Westman and Neville (1942), and two returns resulted. These fish had been at large for only about two months, and had moved only about 15 miles, but the percentage of returns was surprisingly high, especially in comparison with similar efforts in other areas. The next experiments in tuna marking were in the early 1950's, with giant bluefin of the Bahamas, and very small ones off New Jersey. In the former area, cooperating sport fishermen released fish in the 125-300 kg. range (either voluntarily or through breaking of line or leader) with marked hooks furnished by the Woods Hole Oceanographic Institution (WHOI) and the Marine Laboratory of the University of Miami in 1951 and 1952. A few such fish were also marked by members of the latter agency with opercular strap tags. During a run of very small (1.5-2.5 kg.) bluefin off Brielle, New Jersey, late in the 1953 season, 11 of these fish were marked by sportsmen with strap tags furnished by WHOI and the Bureau of Commercial Fisheries. No returns resulted from any of these efforts.

The development of the dorsal loop tag by California workers (Wilson, R.C., 1953) led to the initiation of the present WHOI programme in 1954. Dorsal loop tags were used initially, but were soon phased out in favour of the dart tag developed in that year (Mather, 1963). This not only made it possible to tag fish of the largest sizes, but also made the tagging of small ones quicker and easier. An additional advantage was that fish could be marked without removing them from the water.

Until 1964, most of the tagging was done by sportsmen using equipment furnished by WHOI, and incidentally to research cruises of the Bureau of Commercial Fisheries, WHOI, and other agencies. Effort centred on bluefin tuna, but tunas of other species, as well as istiophorid fishes, were marked when possible. Starting in that year, small bluefin tuna, and, in some years skipjack tuna, were marked in greater numbers by WHOI personnel from purse-seine catches.

In the years 1954-1968, 9,315 bluefin tuna, 2,073 skipjack tuna, 416 yellowfin tuna, and 53 albacore were marked, and returns 1,840 bluefin, 85 skipjack and 1 yellowfin resulted (Table 8). Tags of the many types were used (Figure 1). Fish from rod and reel, longline and purse-seine catches were marked. Return rates were very low until the local purse-seine fishery for small bluefin was greatly expanded in 1962 (Wilson, P.C., 1965). Tagged skipjack tuna were also recaptured in quantity in this fishery in 1964.

Bluefin tuna

The most numerous and important returns were for bluefin tuna, and, due to regional differences in fishing methods and sizes of fish available, most of these can be broken down into five major groups (Table 9). 43 of these returns showed very long migrations (Mather, 1969)(Figure 2). 36 small (4-10 kg. when released) individuals migrated from the northwestern Atlantic bight (Maryland-Cape Cod) to the Bay of Biscay. These migrations evidently occurred mainly between summers, and the grouping of the returns suggests they are much more numerous in some years than in others (Table 10). Even at the maximum, however, they only involved a fraction of the northwestern Atlantic stock. Six returns show migrations of giant (over 150 kg.) bluefin from the Straits of Florida to Norwegian waters. These evidently occur mainly within summers, and one individual took only 51 days to make the 4,200 mile trip. Like those of the small individuals, these migrations appear to vary in volume from year to year. The other long migration was the first recorded crossing of the equator by a bluefin. It was released in the Straits of Florida and recaptured off Recife, Brazil. This indicates that the Japanese longlone fishery in that area in March and April may affect the stock which occurs in the Straits of Florida later in the spring. It may be significant that not one of the 680 giant bluefin marked off the Bahamas has been recaptured in North American waters.

472 bluefin, mostly of medium size (30-150 kg.) were released from longline catches in oceanic waters north of 35°N, and returns have resulted (Figure 3). The relatively high return rate from the 1963 releases may be in part because the fish were multiply tagged and in part because the 1963 and 1964 seasons were the most productive ones in the local purse-seine fishery. The seasonal distribution of recaptures, general further to the northeast as the season advanced, generally follows the pattern indicated by returns from inshore tagging of fish of similar size. An individual estimated as 150 cm. long (about 68 kg.) released about 80 miles south of Nantucket Island in November, 1960, was recaptured off Cape St. Mary's, Nova Scotia, in August 1968; such a period of nearly 8 years is the longest recorded for a tagged tuna, and its weight of 183 kg. when recaptured is a good indication of the time required to replace a stock of large bluefin.

7,734 small (3-75 kg., mostly 3-25 kg.) bluefin were marked in coastal waters between Maryland and Massachusetts, and 1,773 of these were recaptured in the same area. In general, there is a movement from southwest to northeast, as the season advances (Figure 4), but only the larger individuals (over 15 kg.) have been recaptured in the Gulf of Maine. This has occurred in some years only, and recently (1964-1968) there has been a tendency for these fish to return to the westward and concentrate off New York Harbour (Figure 5) in early fall.

The returns from small bluefin tuna are perhaps more important in showing the effects of the fisheries on the stocks, as well as the occasional mass emigrations to the Bay of Biscay which have been noted above. Prior to the change of the purse-seine fishery from a very small strictly local operation to a larger, more aggressive, and seagoing one in the 1962 season, return rates averaged less than one percent of each year's releases. Since this change, return rates of from 15 to 45 percent have been the rule, and sharp declines in effort and in catch since the peak year of 1964 have brough about no corresponding decline in return rates. On the basis of these and other data gathered concurrently, the group of experts on tuna stock assessment which met at Miami in August, 1968, concluded that this stock was certainly small and heavily exploited, and recommended that the landing of individuals weighing less than 10 kg. can be discouraged. (FAO, 1968).

Skipjack tuna

Skipjack tuna were marked in considerable numbers from purse-seine catches in the year 1964-1966 (Table 8) but only in the first of these seasons was there a considerable return. The 71 returns obtained then represented nearly 10 percent of the releases, but these fish had been at large for very short periods and none had moved any great distance. Most of these fish wer 45 to 55 cm. long, which was the dominant size in each of those seasons. The dearth of returns in subsequent seasons, as well as the recurrence of fish of the same size, suggests that fish of this species typically pass through the local fishery only once. It also seems unlikely that they enter other areas of intense fishing.

Yellowfin tuna

Nearly all the yellowfin tuna releases were from longline catches, but the single return was from one which had been caught on rod and reel. It was recaptured at Argus Bank, Bermuda, where it had been released 49 days previously.

Albacore

There have been no returns for albacore. The releases, only 53 in number, were all from longline catches.

Types of tags

All of the many types of tags used have been successful, but some differences in convenience in use, and in effectiveness, have been noted. The type D (Floy FT-1, the standard IATTC tag) is very convenient for tagging fish in numbers when they are taken on board for tagging. When tagging fish in the water alongside the boat, a necessity for large individuals, and evidently a more effective method for small ones, plastic dart tags such as this and our E type (Floy FM-60), suffer excessive breakage compared to tags with stainless steel darts. Also, the broken plastic dart tags tend to jam in the tubular applicators, and these applicators themselves are subject to breakage when used in this manner. The stainless steel tags seem much more rugged and foolproof, and their applicators are not only more rugged, but are less expensive and easier to replace when they are damaged. Little difference has been noted between the return rates for tags in the season of release, but in later seasons (about one year at large, or more) the tags with stainless steel darts show distinctly better return rates. Double and multiple tagging experiments have indicated some shedding, but the results are inconclusive for comparative purposes due to the small numbers involved. In a comparative test, 64 bluefish Pomatomus saltratrix were tagged with type D tags and 63 with H tags. These fish were 50 to 70 cm. long. Despite the seemingly large size of the type H dart for such small fish, six H tags were returned as against only three D tags. The Floy Denison tagging gun (type K tags) has been tried out, and seems to offer good possibilities, especially for small fish and when fish are to be marked in large numbers.

Methods of capture for marking

Nearly all the fish marked were caught by one of three methods; purse-seine, rod and reel, and longline. Due to the different areas and sizes of fish involved, however, and also the changes in fishing intensity over the years, direct comparison of results is not always possible. In the years 1964-1968, however, small bluefin tuna were tagged in considerable numbers in the same general seasons in the coastal waters between Maryland and Massachusetts from both rod and reel and purse-seine catches. The return rates for the rod and reel releases were generally distinctly higher than those from the seine releases (Table 10.). This difference did not always show in the season of the releases, as many of the rod and reel releases were late in the season, after the seine fishery was over, and thus were not available to commercial fishing until subsequent seasons.

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TABLE 8.

Releases and returns for Atlantic tunas tagged by WHOI, by species and years. Returns are before slash, and releases are after slash. Returns are listed by year of recapture.

	Bluefin	Skipjack	Yellowfin	Albacore
1954	1/190			
1955	0/229			
1956	0/99		0/105	
1957	0/39		0/1	0/1
1958	0/38			
1959	4/147	0/1		
1960	0/232	0/1	0/50	0/14
1961	2/186	0/10	0/18	0/3
1962	6/129	0/27	0/3	
1963	19/223	0/12	0/29	0/12
1964	103/575	71/728	0/103	0/20
1965	197/1812	5/438	0/17	0/1
1966	590/4176	9/804	1/21	0/2
1967	715/719	0/26	0/43	
1968	203/521	0/26	0/26	
Totals	1840/9315	85/2073	1/416	0/53

TABLE 9.

Releases and returns for Atlantic bluefin tuna tagged by WHOI, by major tagging areas, size ranges, and methods of capture for tagging: Returns are before slash, and releases are after slash. Returns are listed by year of release. Not all taggings and returns are listed.

Area	Bahamas and vicinity	Newfoundland	Beyond Continental Shelf N of 35° N	Coastal waters Cape Cod - Cape Hatteras	
Size Range	Over 125 kg.	Over 125 kg.	15-150 kg.	3-75 kg.	
Method of capture	Rod and reel	Rod and reel	Longline	Purse seine	Rod and reel
1954	0/21				3/169
1955	0/14				0/215
1956	0/41				0/58
1957	0/0		0/5		1/34
1958	0/0		0/0		0/38
1959	0/25		1/97		0/25
1960	2/13		2/204		1/15
1961	2/34		0/2	0/21	7/129
1962	1/45	0/6	0/1	0/25	4/52
1963	1/147	0/3	5/42		9/29
1964	0/41	0/41	1/25	128/455	3/10
1965	0/55	0/47	0/29	244/1629	17/43
1966	0/105	0/49	0/64	1065/3715	82/184
1967	1/82	0/6	0/3	156/614	1/14
1968	0/57	1/193	0/0	83/219	5/41
Totals	7/680	1/345	8/472	1676/6678	133/1056

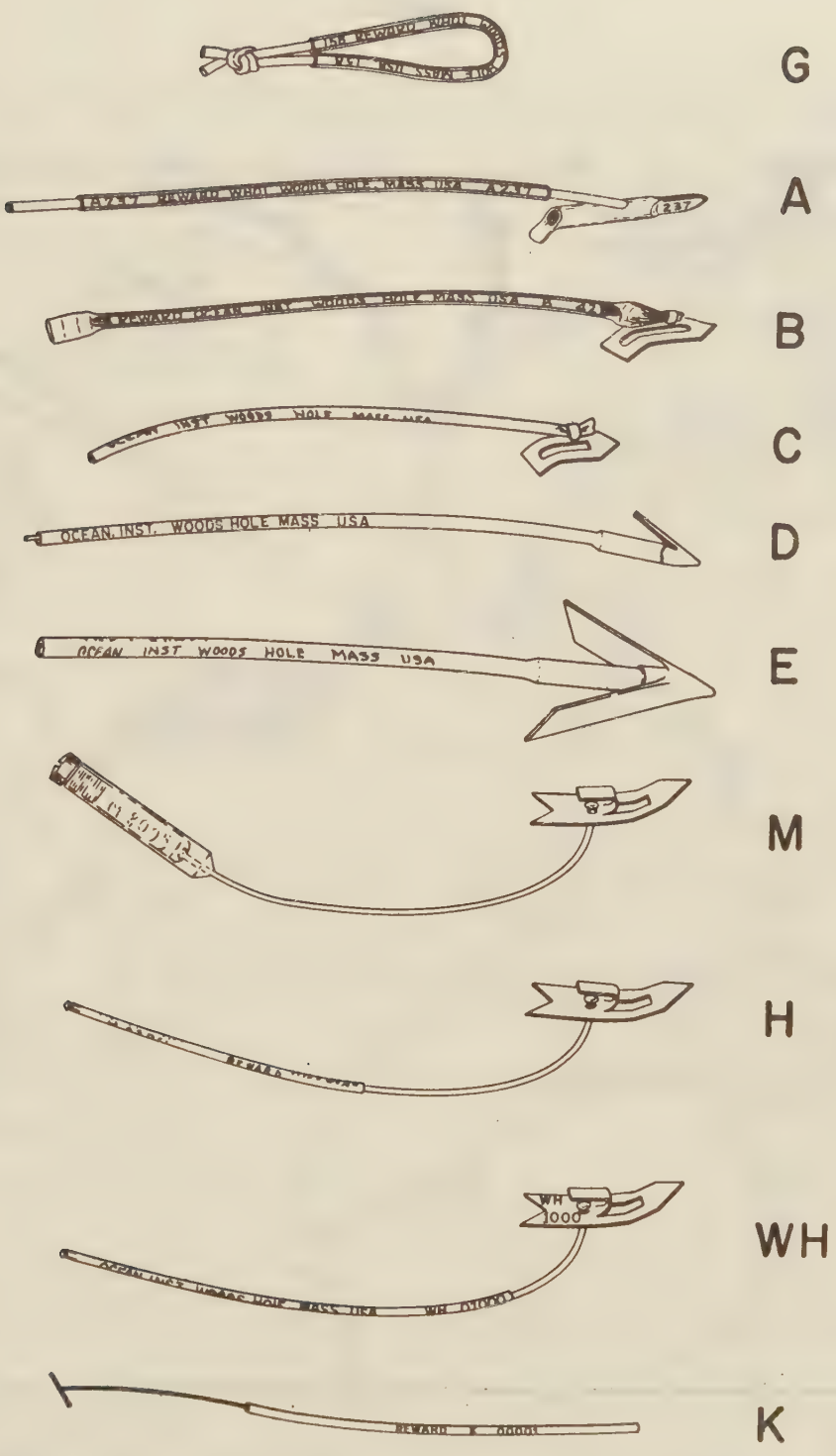
TABLE 10.

Woods Hole Oceanographic Institution
Cooperative Game Fish Tagging Program

Releases of young bluefin tuna in coastal waters between Cape Hatteras, North Carolina, and Cape Anne, Massachusetts, and returns, in percentage of releases, by years, region of recapture, and method of initial capture (S = sport, C = purse seine).

Releases Year	Releases Number	Returns from Release Area Years at Large					Returns from Bay of Biscay Years at Large				Grand Total
		0	1	2	3	Total	1	2	5	Total	
1954S	169	.006	0	0	0	.006	0	0	.012	.012	.018
1955S	215	0	0	0	0	0	0	0	0	0	0
1956S	58	0	0	0	0	0	0	0	0	0	0
1957S	34	0	0	.029	0	.029	0	0	0	0	.029
1958S	38	0	0	0	0	0	0	0	0	0	0
1959S	25	0	0	0	0	0	0	0	0	0	0
1960S	15	0	0	.067	0	.067	0	0	0	0	.067
1961C	21	0	0	0	0	0	0	0	0	0	0
S	129	0	.016	.023	.016	.054	0	0	0	0	.054
1962C	25	0	0	0	0	0	0	0	0	0	0
S	52	0	.077	0	0	.077	0	0	0	0	.077
1963S	29	.241	.069	0	0	.310	0	0	0	0	.310
1964C	455	.214	.068	0	0	.282	0	0	0	0	.282
S	10	.200	.100	0	0	.300	0	0	0	0	.300
1965C	1629	.100	.025	.017	0	.142	.007	.001	0	.007	.150
S	43	.023	.163	.070	0	.256	.047	.093	0	.140	.395
1966C	3772	.131	.140	.012	0	.283	.003	.001	0	.003	.287
S	184	.201	.218	.022	0	.440	.005	0	0	.005	.445
1967C	614	.158	.094	0	0	.252	.002	0	0	0	.254
S	14	0	.071	0	0	.071	0	0	0	0	.071
1968C	219	.379	0	0	0	.379	0	0	0	0	.379
S	41	.122	0	0	0	.122	0	0	0	0	.122

Figure 1



Types of tags used in the Cooperative Game Fish Tagging Programme of the Woods Hole Oceanographic Institute

Figure 2

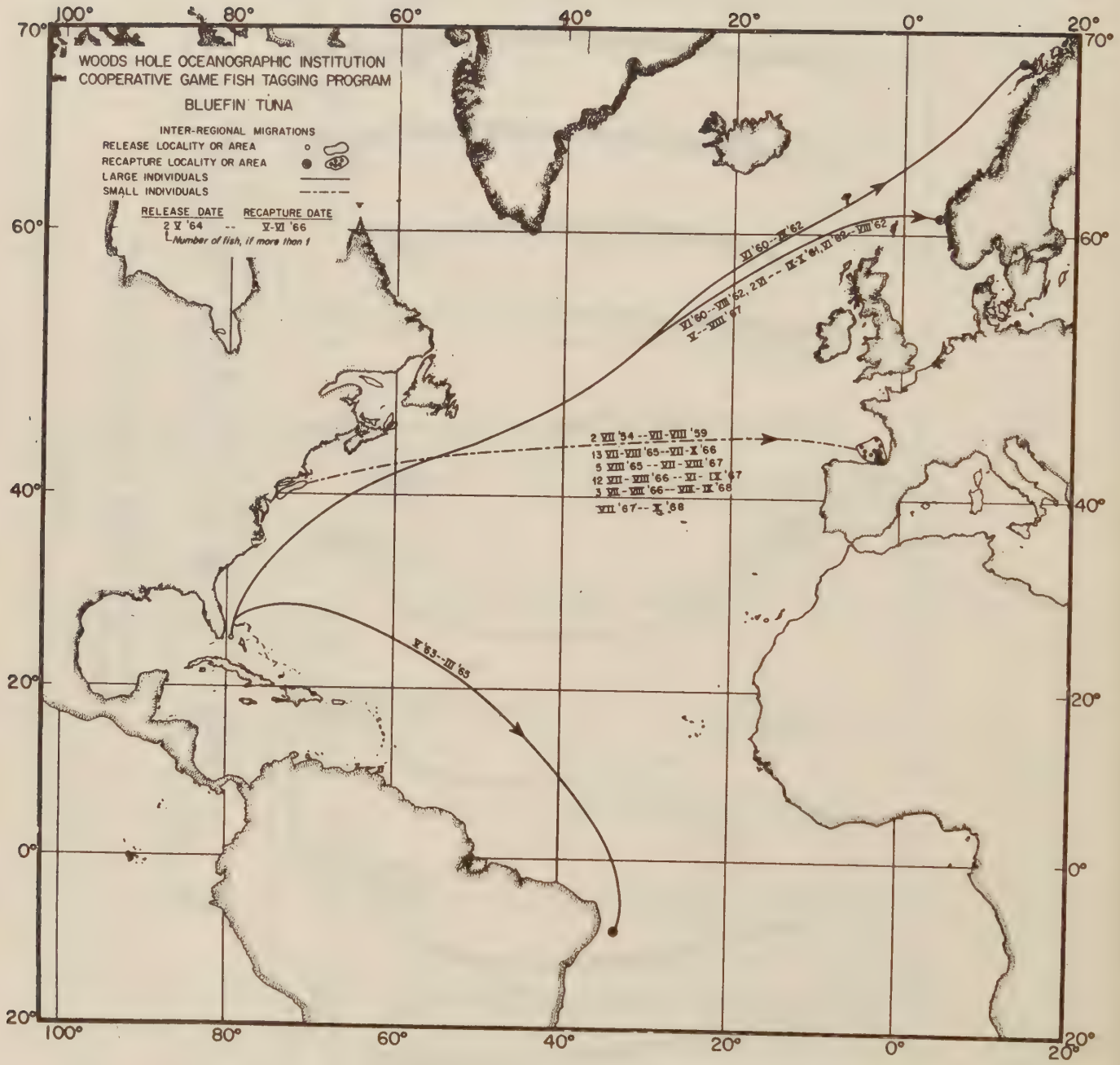

WOODS HOLE OCEANOGRAPHIC INSTITUTION
COOPERATIVE GAME FISH TAGGING PROGRAM
BLUEFIN TUNA
INTER-REGIONAL MIGRATIONS
RELEASE LOCALITY OR AREA
RECAPTURE LOCALITY OR AREA
LARGE INDIVIDUALS
SMALL INDIVIDUALS
RELEASE DATE -- RECAPTURE DATE
2 V '64 -- V-VI '66
Number of fish, if more than 1
VI '60--IX '62
VI '60--VIII '62, 2 VI -- IX-X '61, VI '62--VIII '62
V--VIII '67
2 VII '54--VII-VIII '59
13 VII-VIII '65--VII-X '66
5 VIII '65--VII-VIII '67
12 VII-VIII '66--VI-IX '67
3 VII-VIII '66--VII-IX '68
VII '67--X '68
V '63--III '65
100°
80°
60°
40°
20°
0°
70°
60°
40°
20°
0°

Figure 3

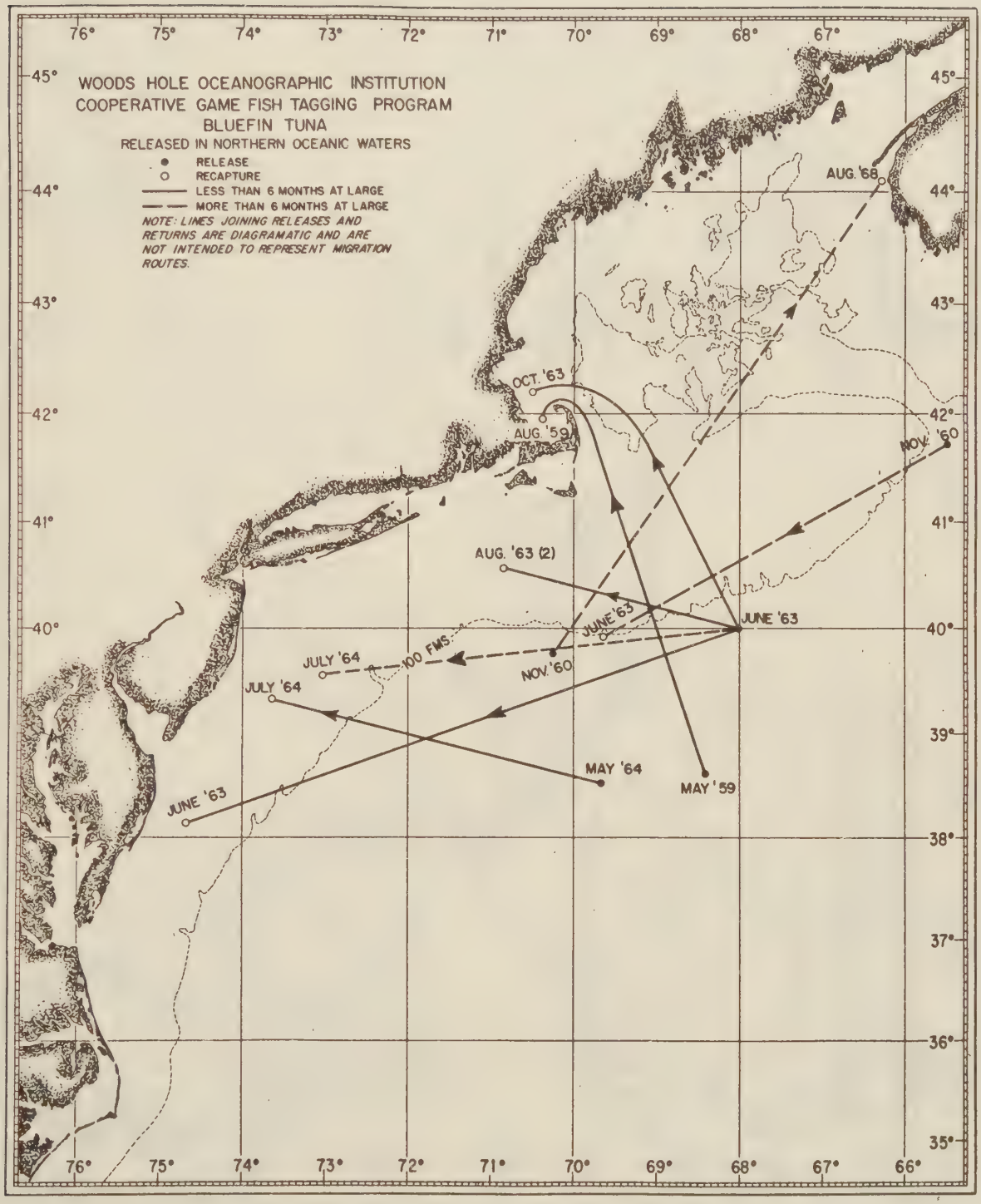

WOODS HOLE OCEANOGRAPHIC INSTITUTION
COOPERATIVE GAME FISH TAGGING PROGRAM
BLUEFIN TUNA
RELEASED IN NORTHERN OCEANIC WATERS
RELEASE
RECAPTURE
LESS THAN 6 MONTHS AT LARGE
MORE THAN 6 MONTHS AT LARGE
NOTE: LINES JOINING RELEASES AND RETURNS ARE DIAGRAMATIC AND ARE NOT INTENDED TO REPRESENT MIGRATION ROUTES.
76° 75° 74° 73° 72° 71° 70° 69° 68° 67° 66°
45° 44° 43° 42° 41° 40° 39° 38° 37° 36° 35°
AUG. '68
OCT. '63
AUG. '59
NOV. '60
AUG. '63 (2)
JUNE '63
JUNE '63
JULY '64
100 FMS.
NOV. '60
JULY '64
MAY '64
MAY '59
JUNE '63

Figure 4

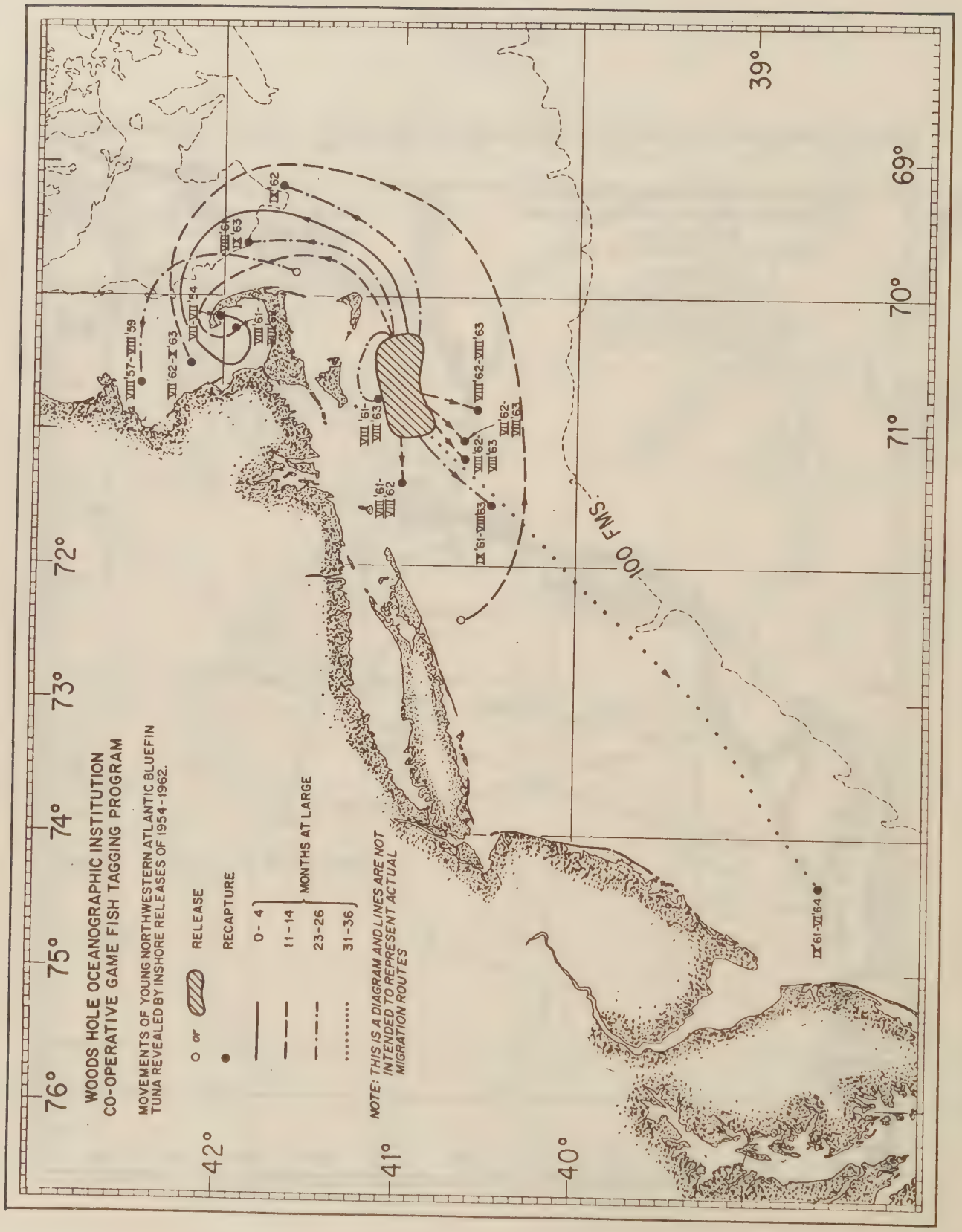
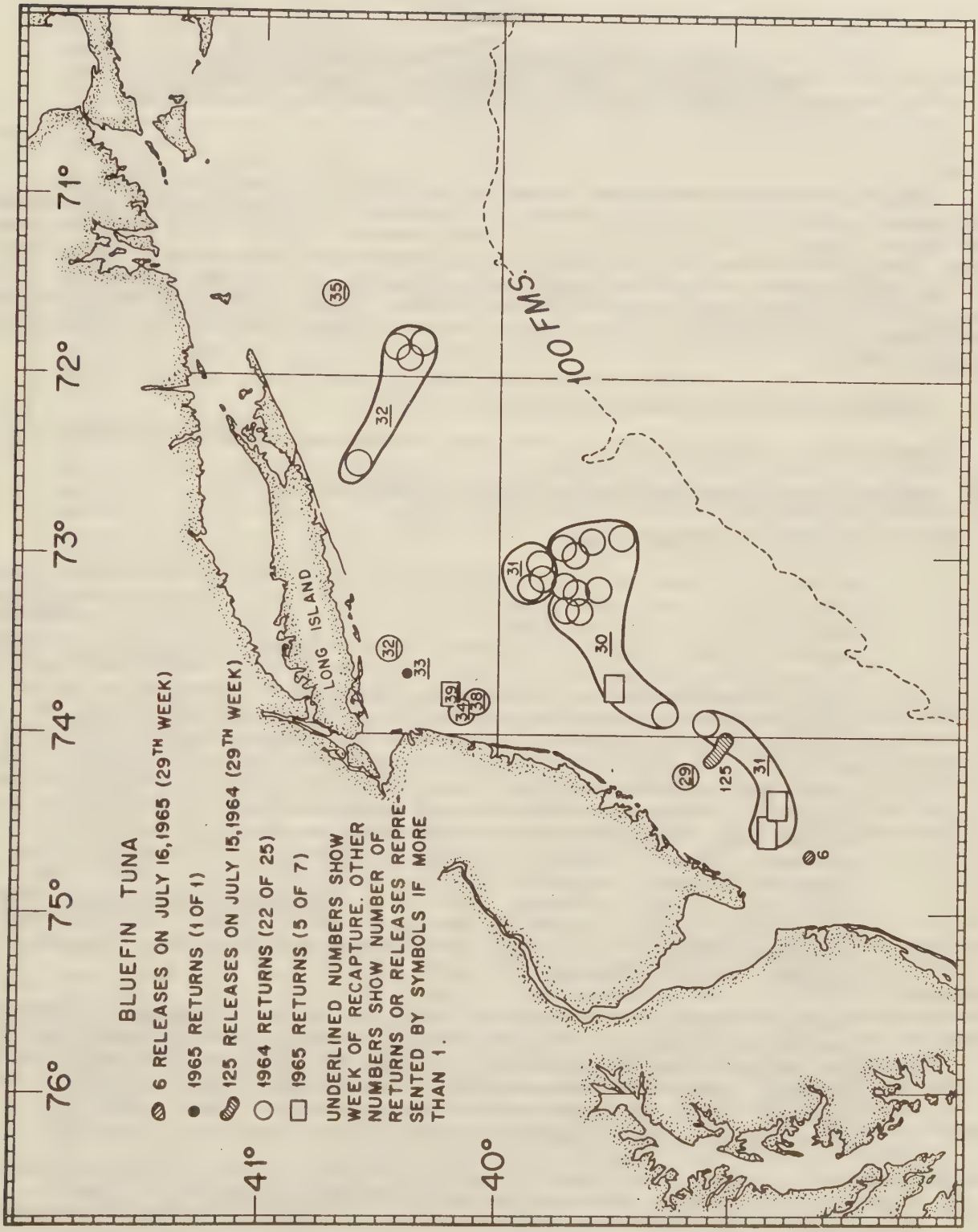

WOODS HOLE OCEANOGRAPHIC INSTITUTION
CO-OPERATIVE GAME FISH TAGGING PROGRAM
MOVEMENTS OF YOUNG NORTHWESTERN ATLANTIC BLUEFIN TUNA REVEALED BY INSHORE RELEASES OF 1954-1962.
O or RELEASE
RECAPTURE
MONTHS AT LARGE
0-4
11-14
23-26
31-36
NOTE: THIS IS A DIAGRAM AND LINES ARE NOT INTENDED TO REPRESENT ACTUAL MIGRATION ROUTES
100 FMS.
76°
75°
74°
73°
72°
71°
70°
69°
42°
41°
40°
39°
VII '62-X '63
VII VIII '54
VIII '57-VIII '59
VIII '61-VIII '63
IX '62
IX '63
VIII '61-VIII '62
IX '61-VIII '63
VIII '62-VIII '63
VII '62-VIII '63
VIII '62-VIII '63
IX '61-VI '64

Figure 5


BLUEFIN TUNA
6 RELEASES ON JULY 16, 1965 (29TH WEEK)
1965 RETURNS (1 OF 1)
125 RELEASES ON JULY 15, 1964 (29TH WEEK)
1964 RETURNS (22 OF 25)
1965 RETURNS (5 OF 7)
UNDERLINED NUMBERS SHOW WEEK OF RECAPTURE. OTHER NUMBERS SHOW NUMBER OF RETURNS OR RELEASES REPRESENTED BY SYMBOLS IF MORE THAN 1.
LONG ISLAND
100 FMS.
76°
75°
74°
73°
72°
71°
41°
40°

APPENDIX 5

REPORT OF THE BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, HONOLULU, TO THIRD SESSION OF THE FAO EXPERT PANEL FOR THE FACILITATION OF TUNA RESEARCH

This report describes actions taken by the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, in response to recommendations made by the FAO Expert Panel for the Facilitation of Tuna Research (EPFTR, First Session, held in Rome, Italy, 8-12 June 1964. This report supplements the Laboratory's report submitted to the Second Session of EPFTR (FAO Fisheries Reports, No. 37) and covers the period July 1, 1966 through June 30, 1969. Each section is preceded by the heading of the particular recommendations as given in the Report of the First Session, FAO Fisheries Reports, No. 18.

1. Identification of Larvae and Juveniles (III-(2))

See report of Working Party on Tuna Eggs, Larvae and Juveniles (Appendix 2).

2. Subpopulation Identification by Genetic Techniques (III-(4))

2.1 Development of Techniques

The Honolulu Laboratory has continued the studies of subpopulations identification of tunas with emphasis on skipjack tuna. In addition to blood group study, gel-electrophoretic studies for enzymes and other proteins from serum and tissues have been successfully developed. Variations of transferrin in serum and of esterases and other proteins in serum and tissues have been found in various species of tunas. A comprehensive application of the inherited characteristics found by the blood typing (immunological) and gel-electrophoretic (biochemical) techniques has been made on 17,000 blood, 1,600 skeletal light muscle, 700 heart muscle, and some liver and skeletal dark muscle specimens from skipjack tuna, 800 blood specimens from yellowfin tuna, and 300 blood specimens from albacore collected from the Pacific and Atlantic Oceans. Many organizations have cooperated in the collection of the specimens. These included the Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, Miami; Inter-American Tropical Tuna Commission (IATTC), La Jolla; INEPACA, a tuna cannery in Ecuador; Service de le Pêche, Tahiti; Fisheries Agency of Japan; Ryukyu Fisheries Research Institute, Okinawa; U.S. Civil Administration of the Ryukyu Islands, Okinawa; and the Government of Guam.

The major findings from the study included (1) the existence of several subpopulations of skipjack tuna in the Pacific and Atlantic Oceans, and (2) the seasonal shifting of the boundary between the different subpopulations in the Pacific. The latter indicates that the subpopulations of skipjack tuna are sympatric in an ecological sense. The results have been summarized in a paper entitled "Immunological and biochemical genetics of tunas."[1/]

1/ Fujino, K. In press. Immunological and biochemical genetics of tunas. Proceedings of the Symposium on Cytogenetics of Fishes, Iowa State University Press, Iowa City.

2.2 Activities of Tuna Blood Group Centre

The Honolulu Laboratory has continued to function as the Tuna Blood Group Centre, with greatly increased emphasis on the skipjack tuna. Serum specimens were exchanged with the IATTC for the purpose of intercalibration of genetic variations in serum transferrin groups found by starch-gel electrophoresis in skipjack and yellowfin tunas. This resulted in a complete agreement in identification of the bands in electrophoretic pattern and the phenotypes found by independent studies of the two laboratories and enabled the direct comparison of the incidences of phenotypes for subpopulation identification.

It has been found inadvisable to have commercial laboratories handle the entire procedure of preparing "standard reagents". If a reagent should contain mixed specificity, it will lead to misinterpretation of results. Purification can be attained only by experienced workers who can obtain the necessary quantity of red blood cell specimens of the fish for intercalibration between the original reagent and the replica.

2.3 Genetic Research

No systematic genetic study has been conducted to acquire broader knowledge on blood groups and inherited proteins in fish. However, population data on serum transferrin group in skipjack tuna have allowed some analysis which resulted in better understanding of the nature of immunological and biochemical genetic characteristics.

3. Tagging (III-(5))

3.1 Tuna Tagging in Palau

In June 1967 the Honolulu Laboratory began tagging skipjack tuna in the Palau Islands, Western Caroline Islands. Palau is the site of a pole-and-line fishery for skipjack tuna and for small yellowfin tuna. Tagging is conducted with the cooperation of the Government of the Trust Territory of the Pacific Islands, by the use of its fishery vessel, Emeraech. Of 392 skipjack tuna tagged in 1967-68, 9 have been recovered. These recoveries indicate a general northeasterly movement of skipjack tuna from Palau into the waters of the Mariana Islands.

3.2 Tuna Tagging in Hawaii

Studies of the summer abundance of skipjack tuna in Hawaiian waters suggested the possibility that skipjack tuna move into the Hawaiian fishery from the northeast. To test this hypothesis, the Laboratory laid plans for releasing large numbers of tagged skipjack tuna in waters to the north and northeast of the Islands. In April-May 1969, 2,486 tuna were caught, tagged, and released during fishing operations aboard the research vessel, Charles H. Gilbert. About 98 percent of the fish tagged were skipjack tuna; the remainder were yellowfin tuna. Most of the releases were made in waters 60-90 miles offshore although the vessels scouted for fish schools up to 300 miles offshore. Scientists aboard the Gilbert also tagged skipjack tuna (and a few small yellowfin tuna) near Nihoa and Necker Islands and French Frigate Shoal while en route to and returning from baiting grounds at French Frigate Shoal. As of June 30, 1969 there had been no recoveries. However, on July 2, one

recovery was made in waters off Makua, Oahu, of a fish which had been tagged 160 miles north of Maui on April 25. This was a skipjack tuna weighing about 1.5 kg.

4. Collection of Larvae and Juveniles (III-(6))
(see also Appendix 2).

Although a standard method of collecting tuna larvae has been agreed upon, the Honolulu Laboratory, in its constant search for an improved gear, obtained several sets of the Brown-McGowan Opening and Closing Plankton Trawl (bongo net). The net will be used for collecting surface plankton samples across the equatorial current system at long. 145°W. As of June 30, 1969, this net was used on two cruises to the equatorial region; one of the cruises was a test cruise to the Line Islands.

On the test cruise, both the bongo and the 1 m net were used, but because of the nearly complete absence of tuna larvae during the cruise period (catch included 3 skipjack tuna, 1 yellowfin tuna, and 1 bigeye tuna larvae in 69 surface and near-surface tows with maximum depth of 30 m), it was not possible to evaluate the comparative performances of the two nets in catching tuna larvae. The bongo net was used only on the first few tows on the second cruise because of technical difficulties (including the loss of a complete unit).

One major disadvantage of the bongo net appears to be that it can be towed routinely only from the stern, and only from vessels with sufficiently low freeboard and compatible deck winch and towing block layout.

The Honolulu Laboratory has resumed midwater trawling for juveniles using a modified Cobb pelagic trawl. The trawlnet is made of 19 mm mesh netting throughout, with a large codend section lined with 6.4 mm mesh netting, and has a mouth opening 12 m high and 8 m wide. Its first use in Hawaiian waters in the summer of 1967 resulted in the capture of 995 larval and juvenile tunas (skipjack, yellowfin, bigeye, albacore, frigate mackerel, and little tunny) in 83 six-hour tows. Most of the larvae and juveniles were 7 - 47 mm long, but a few little tunny and frigate mackerels were as long as 159 mm. On the first cruise to equatorial waters in May-June 1969, the trawl caught 337 larval and juvenile tunas (7 - 225 mm) in 24 six-hour tows. One particularly good tow netted 152 juveniles 21 - 177 mm long.

5. Training, Education, and Exchange (III-(7))

5.1 Cooperation with the Ryukyu Islands Fisheries Research Institute

In May 1968 the Honolulu Laboratory sent three scientists (Richard Shomura, Brian Rothschild, and Tamio Otsu) to the Ryukyu Islands to conduct a 15-day fishery workshop for scientists of the Fisheries Research Institute of the Government of the Ryukyu Islands and of the Ryukyu University. The workshop was sponsored by the U.S. Civil Administration of the Ryukyu Islands. An important facet of the trip was the demonstration of skipjack tagging method for the Ryukyuan scientists. The Fisheries Research Institute now has plans for an extensive skipjack tagging programme in Ryukyuan waters in the near future.

Skipjack tuna constitutes the most important fishery resource of the Ryukyu Islands. The annual landings over the last 40 years has averaged 4,200 metric tons; a record high of 10,900 metric tons was registered in 1959. Virtually all of the fish taken are processed into skipjack sticks (katsuobushi), a large portion of which is exported to Japan.

Because of the similarities in the skipjack fisheries of Hawaii and the Ryukyus, there is close cooperation between scientists of the Ryukyu Fisheries Research Institute and the Honolulu Laboratory in their study of skipjack tuna. Two members of the Institute have spent some time at the Honolulu Laboratory reviewing our work on the skipjack tuna. They are Jiro Isa, presently Director, who spent the period October 1966 - March 1967 in Honolulu, and Akinosuke Tomori, scientist in charge of skipjack tuna studies, who is in Honolulu for the period May - August 1969.

5.2 Visit by Dr. Hiroshi Nakamura

The Honolulu Laboratory sponsored the visit of Dr. Hiroshi Nakamura, an emminent tuna biologist from Japan (formerly Director, Nankai Regional Fisheries Research Laboratory, and presently Consultant, Hoko Fishing Company, Tokyo) to work at the Laboratory. During his visit (April 1967-January 1968), Dr. Nakamura authored a book entitled, "Tuna: Distribution and Migration" which was published by Fishing News (Books) Ltd., London. In this book, Dr. Nakamura synthesized and refined his knowledge of the tunas from his lifetime's research on tunas.

6. Collection, Collation, and Dissemination of Catch and Effort Statistics (III-8))

6.1 Hawaiian Fisheries

In the Hawaiian fisheries, catch statistics are collected systematically for all commercially important species of fish and shellfish by the Hawaii State Division of Fish and Game. Catch reports from the skipjack pole-and-line and the tuna longline fisheries provide information on days fished, area fished, port of landing, catch in weight and number of tunas, billfishes, and other species, and on bait catches.

All catch data, entered on IBM cards, are summarized on a monthly and annual basis; mimeographed reports are distributed to interested agencies. The Honolulu Laboratory, which acts as a repository for the IBM cards, utilizes the information on these cards for various studies on pole-and-line and longline fishing.

In addition to collecting and analyzing catch data from the Hawaiian fisheries, laboratory technicians also conduct biological sampling of the tunas and billfishes caught in these fisheries. Data on length, weight, and sex are collected routinely and entered on IBM cards; these are then used in studies of age and growth, migration, and population structure.

6.2 Operations Analysis

To develop strategies to increase the efficiency of operation of Hawaiian skipjack tuna sampans, the Honolulu Laboratory arranged with Professor Vernon E. Brock of the University of Hawaii to analyze various aspects of the sampan's operations (i.e., fishing, baiting, travel time, scouting time, etc.). This study, based on records provided by the operators of two sampans, identified some of the operations where improvements could lead to an increase in efficiency.[2/]

2/ Brock, V.E., and R.N. Uchida. 1968. Some operational aspects of the Hawaiian live-bait fishery for skipjack tuna (Katsuwonus pelamis). U.S. Fish and Wildlife Service, Special Scientific Report - Fisheries 574, 9 pp.

To broaden the scope of the above-mentioned study and to gather additional information on conditions affecting fishing and baiting, the Laboratory embarked on an "operations analysis" project in the summer of 1967. This observational programme was repeated in 1968. Laboratory technicians, placed on seven sampans in 1967 and on five in 1968, collected detailed data on fishing and support activities for 5-6 days per week. On fishing trips, records were kept on time of departure and return, time scouting started and ended, and time schools were sighted, chummed, and fished. Other data included amount of bait used per school, number of fishermen hooking, number and size of fish caught from each school, types of birds associated with the fish schools, size of the bird flocks, light conditions, and sea height. Data on surface water temperature and salinity were also collected. In port, the time involved in such activities as unloading of fish and loading of ice were recorded. At the baiting grounds, information on area of catch, species and amount caught, and mortalities were recorded. Analysis of the data collected in 1967 has been completed and a preliminary report is under preparation.

6.3 Fishery in Palau

The sampling station established in Palau by the Honolulu Laboratory in May 1965 continued routinely in the collection of operational as well as biological data from the skipjack fishery. Report on the historial development of the fishery and on some aspects of the present operations has been published.3/

6.4 Samoa-based Longline Fishery

The longline fishery based in American Samoa continued to grow at a very rapid rate, both in terms of fishing effort and in landings through 1967. In 1968 the total landings dropped off considerably as did the fishing effort. There was an increase in the proportion of yellowfin tuna landed at the tuna canneries although albacore continued to be the principal species taken. The composition of the fishing fleet, in terms of the country of origin of the vessels, has changed considerably. While Japanese vessels dominated the fleet in the earlier years, there are today more Korean (56 percent) and Taiwanese (39 percent) vessels in the fleet.

Detailed catch and effort data continue to be collected regularly through the cooperation of the cannery and vessel operators. Biological data on the fish landed are collected routinely by the Laboratory's field station personnel. A report describing the history and status of the fishery through 1965 has been published4/ and a follow-up report is under preparation.

3/ Uchida, R.N. 1968. The skipjack tuna fishery in Palau. In J.C. Marr (Ed.), Symposium of the Cooperative study of the Kuroshio and Adjacent Regions (CSK), Report and Abstracts of Papers, FAO Fisheries Report 63, p. 53.

4/ Otsu, T., and R.F. Sumida. 1968. Distribution, apparent abundance, and size composition of albacore (Thunnus alalunga) taken in the longline fishery based in American Samoa,1954-65. U.S. Fish and Wildlife Service, Fishery Bulletin 67(1) : 47-69.

7. Research on North Pacific Albacore and Bluefin (III-(II))

7.1 North Pacific Albacore

A manuscript entitled "Apparent abundance, distribution, and migration of albacore Thunnus alalunga (Bonnaterre) on the North Pacific longline grounds" has been prepared.5/ This report is based on data obtained from Japan through the cooperation of the Japanese Fisheries Agency.

8. Oceanography and Tuna Ecology (III-(12))

8.1 Trade Wind Zone Oceanography

The Trade Wind Zone Oceanography Investigation is designed to further an understanding of the mechanisms which change the distribution of sea water properties and water masses in the North Pacific trade wind zone. To accomplish this objective oceanographic data must be available from which the rate of change of temperature, and salinity at various depths to approximately 1,000 m can be determined. It is also necessary to obtain measures of the large-scale sea-air interactions.

The required oceanographic data were obtained during the field operations phase of the TWZO Pilot Study when a grid of oceanographic stations was occupied at monthly intervals in the area between lat. 10° to 26°N and long. 148° to 157°W, February 1964 to July 1965. This work was reported previously. The oceanographic data and a summary of the descriptive results have been published.

Large-scale sea-air interactions were computed from marine surface observations in the area between the Equator to lat. 35°N and long. 130° to 170°W, July 1963 to June 1965. Two reports are in preparation in which the sea-air interactions are summarized by 5° square units of area and by months. The first report6/ deals with the heat exchange processes: the radiation from sun and sky, the effective back radiation, the heat of evaporation, the conduction of sensible heat, and the net heat exchange across the sea surface. The second report7/ deals with the sea-level wind field and the distribution of wind stresses.

5/ Rothschild, B.J., and M.Y.Y. Yong. MS. Apparent abundance, distribution, and migrations of albacore Thunnus alalunga (Bonnaterre) on the North Pacific longline grounds. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii 96812.

6/ Seckel, G.R. MS. The trade Wind Zone Oceanography Pilot Study, Part VIII: Sea level meteorological properties and heat exchange processes, July 1963 to June 1965. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii 96812.

7/ Seckel, G.R. MS. The Trade Wind Zone Oceanography Pilot Study, Part IX: The sea level wind field and distribution of wind stresses, July 1963 to June 1965. Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii 96812.

8.2 Oceanographic Atlas of the Pacific Ocean

The Oceanographic Atlas of the Pacific Ocean by Richard A. Barkley was published in 1968 by the University of Hawaii Press. It summarizes data from about 50,000 oceanographic stations taken in the Pacific between 1917 and 1965. The 165 charts and graphs which make up the Atlas show the distributions of temperature, salinity, density and dissolved oxygen throughout the upper 2,000 m of the Pacific Ocean, providing a complete three-dimensional summary of what is known today about average conditions in the upper mile of the Pacific Ocean.

Station data on which the Atlas was based have since been used to calculate the three-dimensional distribution of currents and mass transport north of lat. 10°S. This study, which is nearly completed, complements charts and graphs in the Atlas, and makes it possible to estimate eddy mixing coefficients, rates of biological oxygen consumption, and rates of water mass formation.

8.3 Association Between Skipjack Larvae and the Salinity Maximum

The distribution of catches of skipjack larvae, as shown on a chart published by Walter M. Matsumoto,[8/] coincides almost perfectly with those areas of the Pacific Ocean which contain a shallow permanent subsurface salinity maximum. Further examination of this relationship suggests that skipjack tuna spawn in the low salinity surface layer which lies just above the salinity maximum. Since there are three distinct regional shallow salinity maxima (South Pacific, western North Pacific, and central North Pacific), there is a possibility that this relationship could account for the development of subspecies of skipjack in the Pacific Ocean. A manuscript presenting the evidence for this association has been submitted for publication in the Uda Commemorative Papers to be published soon in Japan.[9/]

8.4 Kuroshio-Oyashio Front

A paper published in 1968 showed that eddies in the front between the Kuroshio and Oyashio, just east of Japan, could be considered as an orderly array which resembles a pair of von Kármán vortex streets arranged side by side.[10/] This concept agrees with observed distributions of surface currents, including

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8/ Matsumoto, W.M. 1966. Distribution and abundance of tuna larvae in the Pacific Ocean. In Thomas A. Manar (Ed.)., Proceedings of the Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, pp. 221-230.

9/ Barkley, R.A. In press. Salinity maxima and the skipjack tuna, Katsuwonus pelamis. Bulletin of the Japanese Society of Fisheries Oceanography.

10/ Barkley, R.A. 1968. The Kuroshio-Oyashio front as a compound vortex street. Journal of Marine Research 26(2):83-104

countercurrents, at regular intervals along the front, as well as with the distributions of temperature and density. A more recent analysis pointed out that the compound vortex street, as it was named, should tend to remain more or less stationary as a result of the opposed effects of variation of coriolis force with latitude, and of neighbouring vortices advecting each other. Taken together, these two studies show that the compound vortex street can account for most major features of the frontal system.

9. Behaviour (III-(13))

9.1 Tuna Bait Studies

During 1966 and 1967, the projects on vision, hearing, raft studies, swimming, and feeding behaviour were completed. A new project entitled "Determine alternate live-bait species" was initiated.

Time and motion studies have indicated that skipjack tuna fishermen in Hawaii spend as much as 50 percent of their time (depending upon abundance of bait) fishing for bait in order to fish for tuna. If bait could be cultured and made available, baiting time could be eliminated, thereby increasing fishermen's catches by an amount equal to the percentage of time spent catching bait.

The first questions asked concerned the qualities of desirable bait. What kind of behaviour is desirable in a good live bait? To answer this question, the Hawaiian anchovy (Stolephorus purpureus) was chummed into a tank containing live tuna. The behaviour of the bait and the behaviour of the tuna were observed and recorded. Then a bait that was considered by fishermen to be undesirable (mixture of species of Gambusia, Limia, and Mollienesia referred to as tabai) was tested in the same manner. The two species were then taken to sea and tested on a "wild" school of tuna. Again, the behaviour of the bait and of the tuna were observed and recorded. These methods permitted us to determine the favourable behavioural traits of a good live bait. The results indicated that favourable baitfish were very active, tended to school, if they sounded they returned to the surface when pursued, and took very evasive action when pursued. Also, silvery fish appeared favourable because they presented a stronger visual stimulus.

Several species of baitfish, both freshwater and marine, were tested. These included: Hypothalmichthys molitrix, Puntius javanicus, Notemigonus crysoleucas, Tilapia mossambica, T. heudeloti, Tribolodon hakonensis, and Dorosoma petenense. Of these, the threadfin shad (Dorosoma petenense) appeared to be the best. The shad were tested extensively in 1968 on schools of tuna and proved to be just as good as the Hawaiian anchovy. The shad is euryhaline and, therefore, can be converted from fresh to salt water.

Attempts to culture shad are in progress. Shad have been kept in tanks where they have spawned on two occasions. These eggs, plus eggs brought in to a hatchery from a freshwater reservoir, were successfully hatched, but the larvae eventually died. Shad have been introduced into a small reservoir where they have successfully reproduced.

9.2 Sonar Studies

The CTFM (continuous-transmission, frequency-modulated) sonar project is continuing. Much equipment has been added, so that pertinent data are now recorded on a 14-channel magnetic tape recorder. The data from the sonar are recorded in analogue form on the magnetic tapes. The tapes are brought ashore where the data are digitized and then analyzed with the aid of computers.

The CTFM sonar has been used to observe movements of tuna schools. Diving and swimming behaviour of tuna in relation to their size and to temperature and depths have been investigated.[11] These and other studies, including use of ultrasonic tags, are in progress.

11/ Yuen, H.S.H. 1968. A progress report on the use of a continuous-transmission, frequency-modulated sonar in fishery research. In Jan-Olaf Traung and Lars-Ola Engvall (Compilers), Second FAO Technical Conference on Fishery Research Craft, Seattle, Washington, 18-24 May, 1968, Vol. 2, Part 4-2/VI, 17 pp.

APPENDIX 6

TUNA RESEARCH 1967-69 IN OTHER U.S. LABORATORIES

1. BCF Fishery-Oceanography Center, La Jolla, California

Tuna research in the past two years has been of two categories: fishing technology and fishery oceanography, the latter predominating.

The Operations Research Group has designed, modelled, developed, and built an experimental fast-sinking tuna purse seine net, with some collaboration from BCF Exploratory Fishing and Gear Research Base, Seattle. This net has proved to sink faster and deeper than conventional nets and has been tested at sea by a commercial vessel which has used it successfully on temperate bluefin and albacore, and (with slight modification) on tropical skipjack and yellowfin. If final data support the initial evidence of increased success of sets the net will prove to be a useful, quick-convertible, all purpose net for the tuna purse seine fleet.

The Fishery-Oceanography Group has completed, in collaboration with Scripps Institution of Oceanography and other organizations, a 14-month study of the ecology and environment of tuna in the eastern tropical Pacific Ocean, the EASTROPAC expeditions. Physical and biological data from EASTROPAC are now being processed and will be synthesized, within 12 months, into two data-sets: 1) an oceanographic Atlas and 2) a computer-compatible data bank, stored in NODC, Washington. The Center, and a group of Scripps scientists working on contract for the Center, are now collaborating with BCF, Honolulu, in developing a model of skipjack migration in the EASTROPAC area, based on the seasonal variation in position and strength of the North Equatorial Counter-Current. This work is intended to assist development of a forecasting ability for year-to-year variation in availability of skipjack in the eastern Pacific fishery.

A study of the ecology and oceanography of the Mexican west coast summer fishery for tropical tuna has been completed, by contract, and a model has been developed relating the distribution of tuna not only to banks and islands, but also to tongues of upwelled water moving away from the coast, bearing high densities of tuna forage organisms, around the margins of which yellowfin have been shown to aggregate.

Development of the annual temperate tuna forecasting service based at La Jolla has gone in two directions: ecological studies at sea on the albacore fishery off Oregon and Washington, and establishment of a data communications centre at La Jolla for the automatic reception and analysis of oceanic and atmospheric data from Fleet Numerical Weather Central at Monterey, California. Increasing skill in forecasting atmospheric events developed in the last years by meteorologists is reflected in increasing success in forecasting ocean conditions off the West Coast and in providing useful information to the fishing fleet.

2. BCF Tropical Atlantic Biological Laboratory, Miami, Florida

Studies of the condition of the tuna stocks in the Atlantic, based primarily on analysis of Japanese longline catch records, have continued. The apparent abundance of yellowfin tuna in the longline fishery has increased since 1965, coincident with a decrease in the fishing effort. The recent decrease in Japanese fishing effort in the Atlantic has apparently only been partially compensated in terms of effective fishing effort for yellowfin by the increase in fishing by Korean and Taiwanese vessels.

Reports on the distribution and migrations of albacore, white marlin, and blue marlin have been completed and an atlas of the distribution of deep-swimming tunas and marlins has been prepared. The data suggest that separate populations of albacore in the North and South Atlantic perform seasonal east-west migrations and spawn in the spring and summer on the western side of the two oceans. White marlin migrations in the western North Atlantic have been demonstrated from tagging and fishery data; the species appears to be relatively long-lived and to have a low mortality rate during the time it is available to the fishery.

Information on the distribution and abundance of yellowfin and skipjack tunas in the eastern Atlantic Ocean was obtained and a summary made of American purse seine activity in the eastern Atlantic in 1968. The longline fishery exploits tunas in nearly all parts of the Atlantic, with yellowfin primarily in the tropical, albacore in the temperate, and bigeye in subtropical waters. In 1968, U.S. tuna seiners caught about 9,000 tons of tuna (60 percent yellowfin; 40 percent skipjack) from the Gulf of Guinea south to Angola. Additional studies completed include an analysis of the association of deep-swimming species in the Atlantic tuna fishery, development of a new yield model for optimizing exploited fish populations, based on the Gompertz growth function, analysis of the temporal-spatial relationships among tunas and billfishes caught by longline in the Atlantic Ocean. It is now possible to make inferences about ecological requirements of species such as sailfish and white marlin because of their associations with the more common yellowfin and albacore respectively. Summaries of the food habits of yellowfin, skipjack, and bluefin tunas have been completed. These species appear to feed primarily on a wide variety of fish, crustaceans, and molluscs of generally small size; but fish predominated in stomach samples from the western Atlantic, and crustaceans in samples from the eastern Atlantic. A study was completed on the relation between fishing effort, stock size, and yield of yellowfin tuna of the Caribbean Sea and adjacent regions. The yellowfin tuna resource in the Caribbean is capable of yielding at least 10,000 tons per year at a fishing effort of about 10 million longline hooks. The level of the fishing effort in 1964-65 was about 20 million hooks per year. Studies were begun on the distribution of juvenile scombroids in the Atlantic.

The distribution of tunas in the eastern Atlantic in relation to their environment was investigated in two cruises to West African waters in 1968. With the assistance of vessels of the United States Coast Guard and the Missao de Estudos Bioceanologicos e de Pescas of Angola the area from the equator to 17°S. latitude was studied in a nearly synoptic manner. Yellowfin tuna generally were found north of or at the Gabon-Angola (Berrit) front during its southerly movement, but skipjack tuna were considerably south of the front. Other studies on the relation of tuna and the environment have been completed. The distribution of catch rates in the Japanese longline fishery indicates that deep-swimming yellowfin tuna are distributed around and downstream from the Guinea and Angolan Domes, probably because upwelling in these domes and subsequent enrichment produces good feeding areas.

A monthly wind atlas for the eastern tropical Atlantic Ocean is being prepared for publication. This atlas can be used to relate the seasonal variations in the wind field to the position of the Gabon-Angola front. A preliminary study of the relationship between the Mauritanian-Sierra Leone front off the northwest African coast and the prevailing winds also has been completed. It appears that the position of the front varies seasonally with the frequency of northerly winds. This front is believed, like the southern front, to affect tuna movements. A study of drift bottle recoveries from 1967 and 1968 releases in the southern Lesser Antilles and western Caribbean has been completed. Eddies in the eastern and western Caribbean, with which tuna concentrations may be associated, have been determined.

This laboratory has placed major emphasis on the descriptions of relative apparent abundance of tuna larvae in the Atlantic collected by their vessels as well as those of cooperating agencies and countries. Studies on tuna larvae from the Gulf of Guinea, which were collected on three GERONIMO cruises, have been completed. The tuna larva collected by the international EQUALANT expeditions in 1963 were reported on. Skipjack larvae were present over the entire tropical Atlantic during the two seasons of sampling (February to April and August to November). Yellowfin and bigeye larvae were widespread in the tropical Atlantic in February to April, but were generally absent in the Gulf of Guinea in August to October. Yellowfin and bigeye tuna larvae appear to be limited in their distribution by both temperature and salinity, but this was not so for skipjack tuna. There was little evidence of a correlation between the numbers of larvae and the numbers of adults. The distribution of yellowfin tuna larvae around Annobon Island in the Gulf of Guinea has led to an hypothesis that yellowfin tuna spawn in the Gulf of Guinea in the warm season (November to March), that 1 and 2-year old yellowfin migrate southward seasonally along the African coast and that yellowfin older than 2 years migrate westward into the central South Atlantic.

Internal anatomy of larval tunas was investigated to determine which morphological characters may be useful in identifying scombroid larvae. Differences in kidney length and other structures were found between genera, but species with the genus Thunnus were nearly identical. Several collections of scombroid larvae have been made in the Straits of Florida near Miami and larvae are now being identified. A number of species are included in collections and it is believed that a description of blackfin tuna larvae will result from these specimens. Valuable life colour data have been recorded which may be useful for specific identification of larval tunas. Larvae of the genera Sarda and Scomberomorus are presently being studied.

Larval rearing studies have continued both to study development of pelagic fish larvae and to determine which pelagic species have possibilities for being reared commercially. Larvae of little tuna (Euthynnus alletteratus) have been reared from the egg to 20 days and development of very young stages of this species is being studied. It now seems feasible that artificial rearing of tunas can be carried out, at least at an experimental level.

3. Woods Hole Oceanographic Institution

Recent tuna research has consisted of physiological studies and studies of migrations and populations.

The physiological studies are mainly concerned with the investigation of the tuna body temperature elevation. All of the tunas have the ability to keep their body temperature above that of the water, but so far we have evidence only for regulation of body temperature in the bluefin that is, bluefin tuna can maintain fairly constant body temperature despite changes in water temperature. Bluefin of 350 mm SL already show both the elevated body temperature and the elevated metabolism. To date, efforts to get direct experimental evidence of a regulatory ability is lacking, the evidence for regulation comes from comparing tuna body temperatures with the water temperature from which they were taken.

The major activity in the field of migration and population studies has been a tagging programme, but the sizes of the catches of the local purse seine fishery have also been sampled, and the catch and effort data for the fishery have been recorded as far as possible. The chief subject of these studies has been the bluefin tuna, but considerable effort has been devoted to skipjack tuna also. Further details of the tagging programme are given in Appendix 4.

The main problem at present is to identify the populations, and determine the interchanges between them. For example, the assumed migration from the Bahamas to the northeast coast of the U.S.A. has not been confirmed by tagging, nor has any recruitment from European to American waters.

APPENDIX 7

RECENT ACTIVITIES ON TUNA RESEARCH IN JAPAN; TUNA CATCH AND EFFORT STATISTICS IN JAPAN, WITH SUPPLEMENTARY INFORMATION ON THOSE OF TAIWAN AND RYUKYU

1. Tuna Research

There are two main tuna research laboratories under the Fishery Agency of the Japanese Government; the Far Seas Fisheries Research Laboratory (FSFRL) is in charge of studies on tuna species exclusive of skipjack. Skipjack is studied by the Tohoku Regional Fisheries Research Laboratory (TRFRL).

The basic catch statistics by species of the fishery are compiled by each of these laboratories. The effort and catch statistics processing system of each organization will be explained in a separate paper.

The other important phase of the tuna research project is that both laboratories are assisted by the experimental stations and fishing training schools of many local governments, the number of boats of which amounts to about 50. These local organizations cooperate with them in providing various biological and oceanographic data under the research programme designed by FSFRL and TRFRL. All research groups mentioned above are organized into "the conference for the survey and research of tuna fishery", the annual meeting of which is held under the auspices of FSFRL sponsored by the Fishery Agency. University scientists and industrial people who are interested in tuna research also participated in the meeting.

Principal projects of FSFRL now underway are summarized as follows:

(1) to accelerate stock assessments of various species of large sized tuna, especially Atlantic yellowfin tuna and Southern bluefin tuna;

(2) to examine influences of introduction of new types of fisheries and develop techniques of allocation of catch among fisheries of different characteristics;

(3) to promote surveys on underexploited fish stocks, for instance skipjack and its bait fish.

TRFRL takes charge of the meeting for the forecast of the skipjack fishing twice a year. Major subjects of the laboratory are:

(1) tagging programme of skipjack;

(2) subpopulation study of skipjack in the seas adjacent to Japan.

Staffs of universities, experimental stations and fisheries high schools of local governments are also undertaking various branches of tuna studies. Estimation of population parameters by means of simulation and trials to use echo-sounders as fish counters are noted as attractive examples.

2. Tuna Catch and Effort Statistics

2.1 Japan

2.1.1 Longline fishery. All Japanese longline and live-bait vessels fishing for tunas, including skipjack, larger than 20 gross tonnage, can operate under license authorized by the Fishing Law. Owners of the fishing boats are obliged by law to submit their fishing records in the specified form to the Fishery Agency. In collecting fishing reports prepared by owners, the Federation of Japan Tuna Fishermen's Association, Japan Tuna Fisheries Federation and National Off-Shore Tuna Fishing Association cooperate with the Fishery Agency. The reports submitted are transferred from the Fishery Agency to the Far Seas Fisheries Research Laboratory (formerly until 1967, Nankai Regional Fisheries Research Laboratory), where the reports are processed by utilizing an electronic computer. The data processing is completed within a year after the termination of each fishing season (January to December). In recent years, the amount of data has reached about 200,000 fishing days every year.

Catch statistics, and output of the data processing, are published annually in the "Annual Report of Effort and Catch Statistics by Area on Japanese Tuna Longline Fishery" by the Research Division, Fishery Agency. This series of the report was issued for the years from 1962 through 1967. These catch statistics are compiled in terms of number of fish captured. Under the existing circumstances, it is very difficult to build up complete statistics in terms of weight. Establishment of a system to compile size frequency data seems to be time-consuming because of many reasons which are involved in the longline fishery itself. For instance, accurate daily weight measurement of fish captured on board the vessel is not always necessary for fishermen, and in addition an individual longline boat covers so wide an area that catches from various regions are mixed when they are unloaded at fish markets.

2.1.2 Live-bait fishery. The fishing records of the live-bait fishery are submitted to the Fishery Agency in similar fashion to that described above. Then the presented fishing reports are transferred to the Tohoku Regional Fisheries Research Laboratory for data processing, which has just started this year (1969) by electronic computer. The 1968 data is now under compilation. The results of catch and effort statistics are expected to be published by the Fishery Agency, though the details are not yet decided.

2.1.3 Purse seine fishery. This year the Fishery Agency assigned a new form of catch record, and vessel owners are obliged to fill in the form for every fishing cruise. For the domestic and overseas operations for tuna species, the Tohoku Regional Fisheries Research Laboratory and the Far Seas Fisheries Research Laboratory are expected to be in charge of compiling their catch and effort statistics respectively. Both projects will be started soon.

The Far Seas Fisheries Research Laboratory is planning to compile monthly statistics of overseas operations by tentative unit area for the 1969 fishing season and by 5° square from the 1970 fishing season.

3. Taiwan

The Taiwan Fisheries Bureau published, in 1968, an excellent statistical "Report on survey of production and marketing of Taiwan tuna long-line fishery, 1967". These statistics cover the data for longline boats more than 50 tons.

4. Ryukyu

The system of collecting catch and effort data in Ryukyu is comparable to that of Japan and vessel owners are compelled to submit their fishing records to the government. The "Fishing record form" is also very similar to the Japanese one. The resultant statistics were published in terms of catch and effort by month, 2° square and fish species for 1965 and in terms of hooking-rate frequency of both tunas and marlins by 10 days and 2° square for 1966.

A prompt reporting system of current fishing activities has also been in operation since 1965. It is based on wireless information and is published, every 10 days, in terms of number of settings of lines and amount of catch per setting, by 2° square.

APPENDIX 8

RECENT ACTIVITIES ON TUNA RESEARCH IN FRANCE

The French activities in the field of tuna research, during recent years, have been carried out by the following agencies:

(a) Institut Scientifique et Technique des Pêches Maritimes,
59, avenue R. Poincaré, Paris, XVIe.
Working area: Near Atlantic and Mediterranean Sea.

(b) Office de la Recherche Scientifique et Technique Outre Mer,
24, rue Bayard, Paris, VIIIe.
Working area: Eastern tropical Atlantic and western tropical Pacific.

(c) Centre d'Etudes et de Recherches Scientifiques,
Plateau de l'Atalaye, Biarritz (Basses-Pyrénées).
Working area: Bay of Biscay.

(d) Comité Central des Pêches Maritimes,
11, rue Anatole de la Forge, Paris, XVIIe, in association with the laboratoire d'Océanographie biologique, Faculté des Sciences de Rennes (Ille-et-Vilaine), replaced in 1969 by Centre National pour l'Exploitation des Océans, 39, avenue d'Iéna, Paris, VIIIe.
Working area: Near Atlantic.

(e) Laboratoire de Physiologie. Museum National d'Histoire Naturelle,
57, rue Cuvier, Paris, VIIIe.
Work on material provided by one or other of above agencies.

Investigations being undertaken are as follows:

(1) Exploration, ecology, influence of environmental conditions: a); b); c); d).

For b) this research is being carried out in Dakar (Senegal), Abidjan (Ivory Coast) and Pointe-Noire (Congo-Brazzaville).

(2) Food investigations: b); d).

For b) this research is being carried out in Nouemea (New Caledonia).

(3) Study of age classes from experimental fishing: a); d).

(4) Population studies based on data from commercial catches: b); d).

For b) these studies are being carried out in Dakar, Abidjan and Pointe-Noire.

(5) Tagging: a); c).

a) is concerned with the tagging as well as with the tags from recaptured tunas.

(6) Physiology (including serology sensu lato): d); e).

e) has the leading rôle for all physiological studies.

(7) Sexual development (microscopical anatomy of gonads): b); d).

For b) studies have been carried out in Dakar and Point-Noire.

(8) Parasitology: b); d).

Work of the Institut Scientifique et Technique des Pêches Maritimes in 1967-69

(i) Atlantic

Following on the many tuna research programmes carried out over the past 15 years, new investigations were undertaken in August and September 1967 and from May to September 1968 by the RV "Pelagia", and also in August and September 1968, by the RV "Thalassa".

The purpose of the 1967 programme was to study conditions in the area where albacore collect in August and September in the Bay of Biscay and to try to find out why they disperse and leave this area at a certain time of year. A first study consisted in checking the hydrological conditions in the main fishing grounds used by the tuna fishing fleets, establishing a research method on the basis of the observed correlations and then applying it to a much wider area, which resulted in locating new and important concentrations of albacore in generally similar environmental conditions.

It was thus possible to establish that, within a temperature range of 17° to 21°, medium age group albacore preferred to live on the edge of a layer of warm water found in the southwestern part of the Bay, and that they followed the sometimes quite rapid shifts of this layer. It was also observed that the fish were most abundant when the contact areas coincided with a steep thermocline in the layer immediately below.

Secondly, the observations carried out off the Cantabrian and Galician coasts brought to light the presence of a belt of cold water coming from the West Iberian coast when the prevailing northerly winds blow. This upwelling water is unfavourable to concentrations of albacore and their extension seaward, since it cuts off the warmer current advancing towards the Bay, thus affecting the migration of these tunas, at least the age group frequenting the continental shelf as far as the French sector of it.

In the course of the 1968 fishing season, the research area was extended southwards off Portugal and northwards to the southwest of Ireland.

Length measurements taken on 1,500 fish over a period of two years show four different age-groups of the albacore:

(a) 70 to 88 cm (mean 76 cm);
(b) 60 to 70 cm (mean 63 cm);
(c) 50 to 60 cm (mean 55 cm);
(d) 40 to 48 cm (mean 44 cm).

For activities in the tuna tagging programme see Appendix 4.

(ii) Mediterranean Sea

In July and August 1967 an experiment was organized, with the assistance of the "Plan de relance des Pêches Maritimes", for two trawlers/seiners from Marseille to demonstrate the efficiency of the purse seine for tuna fishing in deep water between the Islands of Hyères and the Gulf of Genoa. The fishing resulted in catches of 10 to 30 tons per set. The fishermen of the longline boats became very interested in the new technique.

In May-June in the summer of 1968, a new research season was carried out by the RV."Ichthys" in cooperation with the fishermen, between the coast of Provence, the Gulf of Genoa and Corsica. The research was based on the evolution of the thermal fronts which are well marked in this area; it was at the limits of these fronts that the best catches of bluefin tuna and albacore were made. The research was continued in 1969, including also the southern part of the Tyrrhenian Sea.

APPENDIX 9

RECENT TUNA INVESTIGATIONS IN SPAIN

The investigations on bluefin tuna (Thunnus thynnus (L.)) which have been carried out for many years, were continued in 1968 and 1969. Work concentrated on the study of the size composition of tunas caught in the trap of Barbate (Cádiz), and the correlation between sea temperature (0-30 m depth) and tuna catches.[1]

An outline on the activities related to tuna tagging is included in Appendix 4.

The biochemical studies comprised of an investigation into copper, iron, manganese and zinc content in the ovaries of tunas and other scombroids (bluefin tuna - Thunnus thynnus (L.); Atlantic little tuna - Euthynnus alletteratus (Raf.); bonito - Sarda sarda (Bloch.); and frigate mackerel Auxis thazard (Lac.)).[2] Investigations have recently been extended to the study of other organs of the tunas; liver, heart, spleen, kidney, pyloric caecum, stomach and intestines. These studies are being performed to determine in which organs the maximum concentrations of these metals are found, with a view to identifying the place of origin of tunas from areas contaminated with materials, mainly radioactive, containing these metals.

Hematological studies comprised of investigations on serum proteins and electrophoretic separation in bluefin tuna during the sexual maturation and post-spawning phases.[3] Also studies on erythrocytic constants, sedimentation rates and biochemical values of the blood of Thunnus thynnus (L.) were carried out. Studies on population genetics and physiological-biochemical aspects are being continued by carrying out electrophoretic research on haemoglobin and soluble mio-proteins.

1/ Rodriguez-Roda, J. (in press). El atún, Thunnus thynnus (L.), del sur de España en la campaña almadrabera del año 1968 y su relación con la temperatura del agua del mar. - Investigacion Pesquera.

2/ Establier, R. (in press). Contenido en cobre, hierro, manganeso y zinc de los ovarios de atún, Thunnus thynnus (L.); Bacoreta, Euthynnus alleteratus (Raf.); Bonito, Sarda sarda (Bloch.) y Melva, Auxis thazard (Lac.); Investigación Pesquera.

3/ Gutiérrez, M. Hematología del atún, Thunnus thynnus (L.) de la costa sudátlantica de España, desde los puntos de vista, citología, bioquímica e inmunología y proteínas solubles total y de tres zonas del cristalino. Investigación Pesquera 31(1) 53-90, 1967; 31(1) 137-143, 1967; 31(1) 161-164, 1967; 33(1) 1-6, 1969; 33(1) 149-161, 1969.

APPENDIX 10

PARTICIPANTS AND OFFICERS OF THE MEETING

PARTICIPANTS

Members of the Panel*/

Dr. Dong Hwan Bae
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Observers

Mr. R. Establier and
Mr. M. Gutiérrez
Instituto de Investigaciones Pesqueras
Cádiz
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*/ Dr. H.Z. Vilela (Portugal) was unable to attend

FAO

Dr. D. Sahrhage
Chief, Marine Biology Section
Fishery Resources and Exploitation Division
Department of Fisheries

OFFICERS OF THE MEETING

Chairman	E. Postel (France)
Vice-Chairman	A. Suda (Japan)
Rapporteur	J. Joseph (U.S.A.)
Technical Secretary	D. Sahrhage (FAO)
Liaison Officer	P. Navea
Interpreters	C. Mouriño R. Skudder
Administrative Secretary	R. Capparucci

APPENDIX 11

LIST OF DOCUMENTATION AT PANEL

Working Papers

EPFTR : 3/WP.1	Provisional Agenda
2	Report of the Second Session of the Expert Panel for the Facilitation of Tuna Research, Tokyo, 15-22 August 1966 (FAO Fish.Rep. 37)
3	Report of the Working Party on Tuna Taxonomy
4	Report of the Working Party on Tuna Length Measurements and Tabulation (Appendix 1)
5	Report of the Working Party on Tuna Eggs, Larvae and Juveniles (Appendix 2)
6	Interim Report of the Working Party on Tuna Tagging in the Pacific and Indian Oceans (Appendix 3)
7	Interim Report of Working Party on Tuna Tagging in the Atlantic and Adjacent Seas (Appendix 4)
8	Report of the Meeting of a Group of Experts on Tuna Stock Assessment, Miami, 12-16 August 1968 (FAO Fish.Rep. 61)
9	Interim Report of the Working Party for the Development and Use of Underwater Sound in Tuna Research
10	International Commission for the Conservation of Atlantic Tunas
11	Some Notes on Genetic Research in Tunas and Subpopulation Identification by Genetic Techniques
12	Notes on the Statistics of Atlantic and Other Tuna Fisheries

Information Papers

EPFTR : 3/Inf.1	Information for Participants
2	List of Members of the Panel of Experts for the Facilitation of Tuna Research and of its Various Working Parties
3	List of Documents (Appendix 11)
4	Statement on FAO Panel of Experts for the Facilitation of Tuna Research
5	Conference of Plenipotentiaries on the Conservation of Atlantic Tunas, Rio de Janeiro, Brazil, 2-14 May 1966 - Final Act
6	Report from the Bluefin Tuna Working Group of the International Council for the Exploration of the Sea (ICES), Copenhagen, May 1968 (ICES Stat.Newslet. 38)
7	Report of the Meeting on the Development and Coordination of Research Programs on Tuna in the Mediterranean, Sicily, 22-24 May 1967 (GFCM)
8	Present Status of Fisheries and Assessment of Potential Resources of the Indian Ocean and Adjacent Seas (FAO Fish.Rep. 54)
9	A Guide to Marks Used for Tunas and an Inventory of Tuna Marking Projects (revised version) (FAO Fish.Circ. 101)
10	Information on a Larvae Net from Japan (Appendix 2)
11	Report of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, to Third Session of the FAO Expert Panel for the Facilitation of Tuna Research (Appendix 5)

EPFTR : 3/Inf.12 Tuna Investigations in the Northeast Atlantic and the Western Part of the Mediterranean Sea. - Work of the Institut scientifique et technique des Pêches maritimes during 1967-1968 (in French)

13 Biological Studies on Bluefin Tuna, Thunnus thynnus, in the Gulf of Cádiz. - Instituto de Investigaciones Pesqueras, Laboratorio Cádiz (in Spanish)

14 Statistical Tables on Tunas, Bonitos, Skipjacks : 1967 (FAO Fish.Circ. 245) and Major Fishing Areas for Statistical Purposes (FAO Fish.Circ. 205 Rev. 2)

15 French Activities in the Field of Tuna Research (in French)

16 An Outline of the Recent Activities on Tuna Research in Japan

17 Catch and Effort Statistics on the Tuna Fisheries of Japan with Some Supplementary Information on those of Taiwan and Ryukyu

18 Tuna Research at the Woods Hole (Massachusetts) Oceanographic Institution

19 Tuna Research 1967-69. U.S. Bureau of Commercial Fisheries, Tropical Atlantic Biological Laboratory, Miami, Florida

20 Tuna Research 1967-69. U.S. Bureau of Commercial Fisheries, Fishery Oceanography Center, La Jolla, California

21 Spanish Tagging Programme on Bluefin Tuna in the Gulf of Cádiz: Barbate and Sancti-Petri (in Spanish)

APPENDIX 12

LIST OF WORKING PARTIES

1. TUNA TAXONOMY

Dr. R.H. Gibbs (U.S.A.) Convener
Dr. B.B. Collette (U.S.A.)
Mr. J.E. Fitch (U.S.A.)
Dr. T. Iwai (Japan)
Prof. E. Postel (France)
Dr. B.J. Rothschild (U.S.A.)
Dr. E.G. Silas (India)
Dr. F.H. Talbot (Australia)
Dr. H.Z. Vilela (Portugal)

2. TUNA EGGS, LARVAE AND JUVENILES

Mr. W.M. Matsumoto (U.S.A.) Convener
Dr. S. Jones (India)
Mr. W.L. Klawe (U.S.A.)
Dr. W.J. Richards (U.S.A.)
Dr. S. Ueyanagi (Japan)

3. TUNA TAGGING IN THE PACIFIC AND INDIAN OCEANS (under revision)

Dr. J. Joseph (U.S.A.) Convener
Mr. J.S. Hynd (Australia)
Dr. S. Kikawa (Japan)
Mr. M. Legand (New Caledonia)
Dr. B.J. Rothschild (U.S.A.)
Dr. H.G. Silas (India)
Mr. P.T. Wilson (U.S.A.)
Mr. M. Yao (Japan)

4. TUNA TAGGING IN THE ATLANTIC AND ADJACENT SEAS (under revision)

Mr. F.J. Mather III (U.S.A.) Convener
Dr. J. de Ciechomski (Argentina)
Mr. J. Collignon (Morocco)
Dr. J.R. Gonzales (Cuba)
Mr. R.C. Griffiths (FAO, Venezuela)
Mr. J. Hamre (Norway)
Dr. S. Kikawa (Japan)
Mr. E.A. Kwei (Ghana)
Mr. J.C. Le Guen (Congo-Brazzaville)
Dr. S. Moura (Brazil)
Mr. A. Percier (France)
Dr. J. Rodriguez-Roda (Spain)
Mr. G.H. Stander (South Africa)
Mr. S.N. Tibbo (Canada)
Dr. K. Tiews (Germany)
Mr. J. Troadec (Ivory Coast)
Dr. H.Z. Vilela (Portugal)

5. TUNA STOCK ASSESSMENT (now disbanded)

Mr. J.A. Gulland (FAO) (Convener)
Mr. J.C. Dao (France)
Dr. J. Joseph (U.S.A.)
Mr. J.C. Le Guen (Congo-Brazzaville)
Dr. B.J. Rothschild (U.S.A.)
Dr. M.B. Schaefer (U.S.A.)
Dr. A. Suda (Japan)
Dr. J.P. Wise (U.S.A.)
Dr. I. Yamanaka (Japan)

6. UNDERWATER SOUND IN TUNA RESEARCH (now disbanded)

Mr. H.S.H. Yuen (U.S.A.) (Convener)
Mr. G.R. Barnard (U.S.A.)
Dr. D.H. Cushing (U.K.)
Mr. J. Hamre (Norway)
Dr. F.J. Hester (U.S.A.)
Prof. M. Nishimura (Japan)
Dr. E.V. Shiskova (U.S.S.R.)

7. RESEARCH ON NORTH PACIFIC ALBACORE AND BLUEFIN TUNA

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